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AN ANALYSIS OF
THE NAVAL SUPPLY SYSTEMS COMMAND'S
ENGINEERING THE WORKPLACE (EWP) PROJECT

by

Patrick Alan Elliott

June 1988

Thesis Co-advisors: Thomas P. Moore
Raymond W. Smith

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by

Patrick Alan Elliott
Lieutenant Commander, Supply Corps, United States Navy
B. A., San Jose State College, 1971

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Author: Patrick Alan Elliott

Approved by: Thomas P. Moore, Thesis Co-advisor

Raymond W. Smith, Thesis Co-advisor

for

David R. Whipple, Jr., Chairman
Department of Administrative Sciences

James M. Fremgen
Acting Dean of Information and Policy Sciences

ABSTRACT

The purpose of this thesis is to evaluate the current Naval Supply Systems Command stock point productivity enhancement project known as Engineering the Workplace (EWP). It was found that EWP produced significant efficiencies in physical distribution work methods, employee performance, and material organization and flow. It was also found that EWP is an effective tool for training employees in efficient work methods, monitoring employee performance on a continuing basis, and providing managers with a quantitative decision making control mechanism that is based on objective performance measurement indices. The major conclusion is that EWP is an appropriate methodology to use in other functional areas of a stock point. An aggressively managed application of EWP throughout other segments of the NAVSUP community may significantly improve productivity.

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I. INTRODUCTION

A. BACKGROUND

The first half of the decade beginning with 1980 witnessed the greatest peacetime growth in United States defense forces of any period in history. A significant portion of the Department of Defense (DOD) Budget was earmarked to procure and support a 600-ship Navy, a force level which became the goal of the Reagan Administration and a rallying cry for its chief proponent, then Secretary of the Navy, John Lehman.

Concomitant to the growth in Navy procurement and research and development accounts were increases in the operation and maintenance appropriations which funded the Naval Supply Systems Command's (NAVSUP) material logistics network. A Navy which was increasing its operating forces and broadening the scope of its mission areasinspired a complimentary expansion in the capability of its logistics support infrastructure.

To support a changing Navy that was growing in both size and sophistication, NAVSUP management worked to raise the effectiveness of supply support by integrating state-of-the-art business, information systems, and material handling technology into the activities throughout its area of responsibility. The inventory control points (ICPs)

whichmanaged the worldwide inventories of Navy material and the stock points which maintained and distributed those inventories were the focus of most of this technological transformation within the NAVSUP community.

The supply system inventory and financial inaccuracies experienced during the 1970s coupled with the reality that existing logistic data processing networks had distinct limitations on their ability to handle additional workload, gave rise to several improvement projects designed to enable the supply system to:

- adequately cope with future projected workload,
- resolve problems caused by incompatibilities between the various logistic data networks,
- erect the framework within which future supply system enhancements might be developed.

The Stock Point Logistics Integrated Communications Environment (SPLICE), Stock Point ADP Replacement (SPAR), Navy Integrated Storage Tracking and Retrieval System (NISTARS), and Inventory Control Point Resolicitation were the principal projects chartered to transition the Navy supply system into a state-of-the-art business enterprise.

By the mid-1980's the DOD funding environment had changed significantly. Congressional budget and deficit reduction pressures were forcing defense leaders to redefine their priorities in the face of dwindling resources.

NAVSUP leadership realized that the technology investment projects were the keys to modernizing the supply

system. However, the schedules of some of the principal projects (SPLICE, SPAR, and NISTARS) had slipped significantly after they had undergone several scope changes and cost increases. What was needed was a way to make existing supply operations more efficient without compromising the quality of logistic support; a way of responding positively to resource decreases by making operational economies while maintaining logistic response and availability levels. NAVSUP conducted research in the commercial sector and observed several ways in which private companies were improving efficiency while maintaining the quality of their products. One particular productivity enhancement process became the foundation for a project, called Engineering the Workplace, which NAVSUP decided to apply at several of its stock points.

B. ENGINEERING THE WORKPLACE (EWP)

Engineering the Workplace (EWP) is a productivity enhancement methodology, based upon modern industrial engineering principles. It is being applied primarily in the physical distribution functions at seven of the eight Naval Supply Centers. Borne out of a 1986 NAVSUP initiative, the EWP project is intended to:

- improve operational efficiency,
- improve personnel utilization, and
- decrease operating costs.

A maxim which appears in the Process Control Office at the Naval Supply Center (NSC) Pensacola, Florida epitomizes the fundamental precept of EWP:

- You can manage what you can measure, and you can measure what you can define.

Although the goal of EWP is to effect cost saving operating efficiencies, the thrust of EWP is the transformation of attitudes; the attitudes created by the commitment of management and workers to improve productive work processes and to do quality work the first time; attitudes which form the foundation on which sound supply business operations may flourish.

WP is a task based methodology comprised of three distinct procedures:

- Analyzing and reorganizing the material flows in an operation to effect process efficiencies,

- Developing engineered performance standards and statistical process control mechanisms to effect productivity enhancements and maximize worker utilization,

- Instituting a management information data system which allows managers at all levels to measure performance and plan utilization.

A more detailed review of EWP methodology, including a description of the functions of those responsible for the implementation of EWP, will be presented in Chapter II of this thesis.

C. FOCUS OF RESEARCH

The primary thrust of this study is to discuss, analyze and evaluate the Engineering the Workplace (EWP) project as it is being implemented at three Naval Supply Centers (NSCs): NSC Pensacola, Florida; NSC Jacksonville, Florida; and NSC Oakland, California. Data from each research site will be examined for those factors, internal and external to the activity, which contribute to the effectiveness of each unique EWP application. Productivity measurements from NSC Pensacola will be analyzed to determine if there is a significant increasing or decreasing trend, and to determine the frequency and magnitude of work process improvements.

The goal of the research is to provide the Naval Supply Systems Command (NAVSUP) with an objective independent analysis to help them determine the effectiveness of EWP and its exportability into other functional areas. A secondary goal of the research is to present a compendium of EWP benefits that have been realized at each research site (as of the date of the research) to provide the reader with an indication of what could be expected in future EWP implementations.

D. RESEARCH QUESTIONS

Based upon the research goals offered above, the following primary question will be addressed in this study:

- Is Engineering the Workplace (EWP) an appropriate methodology to apply to other than stock point physical

distribution functions, and if so, into what other areas might EWP be exported?

To support the primary research question, the following subsidiary questions will be addressed:

- What productivity enhancements have been effected via EWP implementation?
- Have individual applications of EWP been tailored to accommodate unique stock point working environments?
- What tradeoffs to successful EWP implementation have been encountered which might be of significant detriment to future site implementations?
- What workforce productivity trends have been experienced in the course of EWP implementation which might provide insight into future expectations?

E. RESEARCH METHODOLOGY

The information presented in this study was obtained from the Naval Supply Systems Command (NAVSUP), available literature, and from three Naval Supply Centers (NSCs) via primary and secondary research. The NSCs were selected for this study by virtue of their respective estimated levels of EWP project completion:

- NSC Pensacola: 95%,
- NSC Jacksonville: 50%,
- NSC Oakland: 15%.

Primary research consisted of personal interviews of key individuals at each of the selected supply centers. The framework of the interviews was developed from selected questions identified during review of the available literature. Local documentation, activity records and

reports, and firsthand observations were also primary data used in this study.

The secondary research methodology used was a comprehensive review of the literature. The review was done to familiarize the researcher with the fundamental industrial engineering and material handling principles of the EWP procedure. The literature was obtained from several sources including the Naval Supply Systems Command (NAVSUP), the Naval Postgraduate School library, Naval Supply Center (NSC) Pensacola, NSC Jacksonville, NSC Oakland, Advanced Technology Incorporated (ADTECH), and H.B. Maynard and Company, Incorporated.

F. SCOPE OF THE STUDY

This study is limited to examining the implementation of EWP at the three aforementioned Naval Supply Centers (NSCs) selected for research.

The study focuses on the separate EWP implementation experiences encountered by each activity and analyzes and evaluates key performance improvement indices. Additionally, a compilation of recommended work process improvements will be presented.

G. ORGANIZATION OF THE STUDY

Chapter II provides a detailed examination of the EWP methodology after a brief description of the environment

which led to the implementation of such a project within the supply community.

Chapter III presents the pertinent information gathered from the data sources in a manner which facilitates the understanding of the major outputs of EWP: performance, utilization, and productivity. Charts and tables are provided to illustrate the relationship of EWP outputs to inputs.

Chapter IV analyzes and evaluates the data presented in Chapter III via trend and time series regression analyses. Graphs are provided to enhance the meaning of the analysis.

Chapter V provides the conclusion of the research study which ties the data presentation and analyses of Chapters III and IV to the primary and secondary research questions. Chapter V also offers recommendations to aid in the implementation of future EWP efforts.

II. BACKGROUND

A. INTRODUCTION

This chapter examines the reasons the Navy chose Engineering the Workplace (EWP) as a vehicle to enhance productivity at selected Navy stock points. The chapter also describes the business environment which supported the decision to implement EWP, then tells how EWP was supposed to improve productivity, and how soon productivity improvement and thus savings were to be realized after implementation.

1. The Genesis of Engineering the Workplace

The early 1980s saw steady growth in the Naval Supply Systems Command's (NAVSUP's) operation and maintenance (O&MN) budgets. These budgets peaked in 1983-1984. During that "watershed" period, Navy Supply System management forecasted a period of eight to ten years of declining supply funding, whereas other Navy operations accounts were forecasted to increase. [Ref. 1] Figure 2-1 graphically displays the actual and projected NAVSUP resource base for 1984 through 1994. [Ref. 2]

The only projects approved in the NAVSUP budget in 1984 pertained to long range automated data processing (ADP) equipment and software modernization. These were the Stock Point ADP Replacement (SPAR), Stock Point Logistics

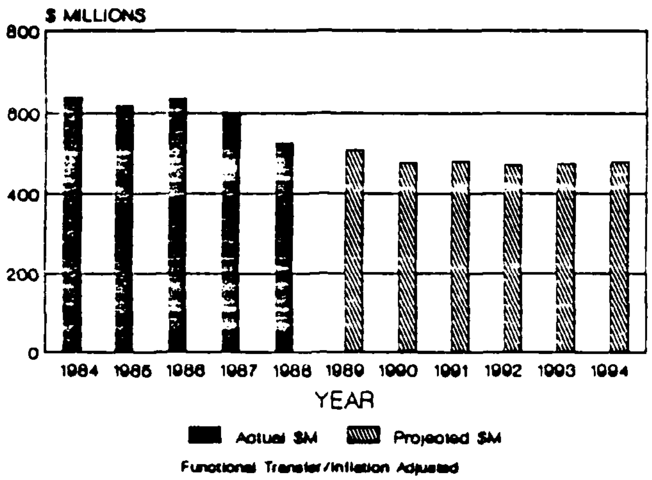

Figure 2-1 NAVSUP Resource Base

Integrated Communications Environment (SPLICE), and Resolicitation projects. Stock Point ADP Replacement (SPAR) was being developed to improve stock point operations through hardware and software system replacement. The Stock Point Logistics Integrated Communications Environment (SPLICE) was being developed to provide telecommunications support and interactive transaction processing to stock points and selected field activities. [Ref. 3] Resolicitation was being developed to improve inventory control point (ICP) operations through hardware and software system replacement. SPAR, SPLICE, and Resolicitation represented multi-year investments of several billion

dollars that were still in the design, development and pre-implementation stages with tangible benefits expected several years in the future.

In a 1984 strategic planning conference, Naval Supply System management considered the austere funding and resource picture for the coming years. Against this backdrop of dwindling resources, NAVSUP decided to look at ways to enhance the efficiency of its existing operations until the full implementation of SPAR, SPLICE, and Resolicitation. Ruled out were decisions to accelerate the SPAR, SPLICE, and Resolicitation projects. Long range improvements like military construction and automated material handling systems were also excluded. The central question posed was, "What can we start today that will enable increasing workload to be done with decreasing resources?" [Ref. 4]

A common sense approach was taken by NAVSUP's Deputy Commander for Physical Distribution (Code SUP 06) who advocated first finding out what private companies were doing along this line, comparing and evaluating their respective programs, and then selecting the most adaptable of the methods as candidates on which to base a choice of contractors. After several months of study in the commercial sector, NAVSUP researchers found that companies which had implemented engineered performance standards

together with incentive pay programs showed the greatest sustained increases in worker productivity. [Ref. 1]

The physical distribution functions at the smaller supply centers were chosen over other possibilities for the initial application of the efficiency enhancement project within the NAVSUP community. NAVSUP Management reasoned that at Navy stock points, as in private industry, the traditional physical distribution functions of material receiving, segregating, stowing, and issuing lent themselves most appropriately to the application of engineered performance standards where human effort could better be measured and productivity more easily ascertained. Of the smaller stock points envisioned to initially apply the project, Naval Supply Center (NSC) Pensacola, Florida was selected as the prototype site for engineered performance standards implementation. As the newest supply center, NSC Pensacola had a smaller workforce and workload tasking than other Navy stock points, and it possessed physical distribution facilities considered ideally configured for maximizing productivity enhancements. The rationale behind selecting NSC Pensacola as a prototype was straightforward; applying such a project first at a small activity would mean that adjustments in the methods of implementation would be easier to make. These adjustments could then be adopted when applying the project at follow-on activities.

NAVSUP considered alternative efficiency enhancement methodologies which had demonstrated impressive payoff in the manufacturing and retail segments of private industry. One methodology was based on the statistical quality control techniques and concepts advocated originally by Dr. Edward M. Deming in the 1940s. Deming's methodology was applied successfully in the Japanese economy and is gaining wider acceptance in U.S. industry. The other methodology was based on the engineered performance standards and process control concepts of modern industrial engineering disciplines, a methodology which has been implemented successfully throughout U.S. industry.

Contractors representing both of the above methodologies were selected as candidates to compete for a NAVSUP contract. In 1986, a cost plus fixed fee contract was awarded to Advanced Technology Incorporated (ADTECH), of Reston, Virginia to develop and install management improvements at designated Naval Supply Centers based upon industrial engineering methods. As stated in the contract, it was NAVSUP's desire to:

> ...apply state-of-the-art, industry-proven management techniques to improve the effectiveness and efficiency of supply center physical distribution operations while reducing the cost. [Ref. 6:p. 22]

The objectives cited in the contract's statement of work gave ADTECH a broad charter to:

- Determine and correct problems,
- Increase productivity in terms of quality, quantity, and timeliness,
- Improve utilization,
- Improve performance,
- Decrease cost of operations, and
- Provide for continous improvement of operations.

Engineering the Workplace (EWP) was initiated, approved, and funded as a NAVSUP project (via Office of the Chief of Naval Operations {OPNAV Code 41} sponsorship) less than one year after the original idea was conceived. Because budget leadtime was insufficient to program for the project and because efficiency benefits were expected to exceed investment costs, NAVSUP funded EWP from its own budget resource base. However, NAVSUP envisioned receiving follow-on funding through the Office of the Chief of Naval Operations, Deputy Commander for Logistics (OPNAV Code 04) for the outyears after project success could be demonstrated at the prototype site. [Ref. 4]

Specific implementing objectives, designed to maximize EWP benefits, called for:

- Cost justifying methods improvements via:
  - maximizing immediate productivity gains,
  - increasing material accountability,
  - the pragmatic use of technology, and
  - simplifying work procedures;
- Optimizing employee performance through:

  - reducing the size of the workforce,
  - cross training workers in other tasks,
  - increasing employee productive work time, and
  - increasing the speed of work accomplishment;
- Improving the quality and economy of operations via:
  - instituting management control tools,
  - using workload and resource planning methods,
  - creating a lean management profile, and
  - use of budget planning tools. [Ref. 7:p. 1]

2. <u>EWP Scope and General Methodology</u>

The original contract with ADTECH included five supply centers in the EWP implementation plan:

- NSC Pensacola, Florida,
- NSC Jacksonville, Florida,
- NSC Charleston, South Carolina,
- NSC Puget Sound, Washington, and
- NSC Pearl Harbor, Hawaii. [Ref. 7:pp. 4-19]

The largest supply centers, NSCs Oakland and San Diego, California, and NSC Norfolk, Virginia were not included in the original purview of EWP because those centers were implementing the Naval Integrated Storage, Tracking and Retrieval System (NISTARS). The NISTARS project included the installation of facilities, automated material handling systems hardware and software, and the performance of comprehensive material flow analyses.

NSCs Oakland and Norfolk, and the Ships Parts Control Center (SPCC) Mechanicsburg, Pennsylvania have since been included within the EWP charter (SPCC being the first NAVSUP activity to apply EWP to the clerical area in their weapon system provisioning section). Using the concepts of Edward Deming, NSC San Diego has embarked on a separate efficiency project.[1] At present, seven of eight Naval Supply Centers and one Inventory Control Point are implementing EWP in at least one of their primary functional areas.

Before beginning EWP at any of the selected sites, several points of understanding were agreed upon by the contractor and Navy EWP project managers. These points were integrated into implementation plans:

- Although the supply centers performed similar physical distribution functions related to material management and movement, each had a unique configuration of land, buildings, space layout and automation.

- The volume of workload, mix and quantity of items carried, and type of customers supported varied considerably by site.

- The mission, organization, and functions of each center varied.

- The workforces themselves and local labor representative organizations differed.

- Application of EWP methodology, particularly standards establishment and performance measurement, should reflect site uniqueness. [Ref. 4]

---

[1]The NSC San Diego efficiency project is not included within the scope of this research.

Site implementation of EWP occurs via three interrelated tasks. Task A is called the material flow analysis. It consists of an engineering study of the flow of material and the accompanying documentation throughout all physical distribution functions so recommendations may be proposed which:

- improve the quality, quantity, and timeliness of material flow,
- optimize storage,
- minimize movement of material and documentation, and
- provide alternatives which represent the least cost to the Government as well as being the most beneficial to overall Navy supply distribution operations.

The material flow analysis (MFA) is intended to identify improvements which promise relatively quick payback (less than three years), and potentially high return on investment. The MFA looks closely at:

- whether material is located in the right building,
- whether the material locations within a building optimize storage and minimize the movement of material and documentation, and
- whether material flow enhancements such as storage aids or automated material handling systems should be recommended.

Task B consists of developing engineered performance standards at the worker level which are site unique. Quality, quantity and timeliness of work performed by each individual worker is statistically charted, measured and evaluated to render standard units of work measurement for each separate work function. Task B uses the Maynard

Operation Sequence Technique (MOST) as the industrial engineering tool to develop performance standards. MOST is a modern work measurement procedure which evolved from the time studies of Frederick W. Taylor and motion studies of Frank and Lillian Gilbreth. MOST is a proprietary technique of H.B. Maynard and Company, International Management Consultants, who are subcontractors to ADTECH for EWP implementation. In Task B, the contractor has developed statistical process control software for microcomputers and stand-alone minicomputers. The results desired from Task B include providing first and second level supervisors with the ability to evaluate and control work processes and to schedule labor for maximum work efficiency and worker utilization. [Ref. 6:pp. 23-26]

Task C involves creation of a personal computer based software support system, the EWP Productivity Enhancement System (EWPPES), which enables management, from first level supervisors to the Commanding Officer, to monitor aggregate productivity measures based on the unique engineered standards developed under Task B. EWPPES integrates the labor scheduling and statistical process control features of Task B to provide management the capability to quantitatively measure group productivity for workload projections, performance evaluations, resource allocations, and budget determinations. [Ref. 8]

Figure 2-2 shows a task implementation schedule for NSCs Pensacola, Jacksonville, and Oakland based on information from the EWP contract. [Ref. 6]

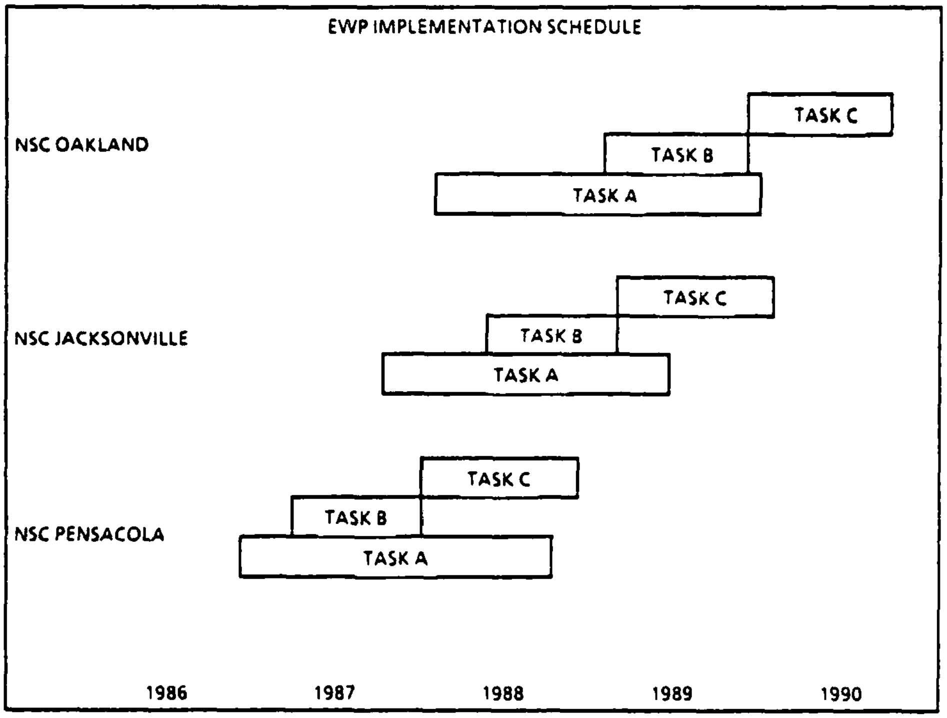

Figure 2-2 EWP Task Implementation Schedule

3. <u>Detailed EWP Methodology</u>

How EWP is implemented directly reflects the uniqueness of each subject site and carefully considers the individual characteristics mentioned previously as acknowledged points of understanding between the contractor and EWP project managers. The following sections describe a

physical distribution application of EWP at a generic stock point to provide an understanding of the composition and responsibilities of the implementation team and of the task relationships and timeframes involved.

a. The EWP Implementation Team

The EWP implementation team is comprised of representatives from NAVSUP (Code 0621), ADTECH, H.B. Maynard and Company, and the application supply center. Although the contractor, ADTECH, is responsible for carrying out the terms and conditions of the EWP contract, the implementation team provides a technical and organizational support framework which helps the contractor with data gathering, information access, and government relations. All but the NAVSUP representative are typically co-located at the site in an EWP project office situated near physical distribution areas and with access to required information sources.

b. Analyzing the Material Flow

Analyzing the material flow is the Task A action which requires the contractor to evaluate how material moves throughout the stock point, from the point of receipt to the point of issue. The contractor must also determine what instructions govern the movement of the material.

First, the EWP team achieves an understanding of the factors internal to the activity which will affect project implementation (the activity's mission, tasks, and

functions). Next, the EWP team develops an understanding of the factors external to the activity which will affect project implementation (directives from higher authority which describe the activity's operating environment and performance goals). Then, a detailed study of the characteristics of the physical distribution function (facility location and condition, degree of automation, workload, workforce, etc.) is made. Additionally, the EWP team becomes familiar with the features of the supply business environment within which the center must work (Uniform Automated Data Processing System for Stock Points {UADPS-SP}, Navy Automated Transportation Documentation System {NAVADS}, etc.).

After developing an understanding of the activity and its environment, the EWP team establishes goals for the material flow system. At NSC Pensacola, the following were some of the goals established:

- Effectively integrate productivity enhancing projects into the activity,
- Develop an efficient, flexible warehouse layout and operations plan that will accommodate increased demands,
- Introduce procedures, policies and systems that will help personnel do their jobs better,
- Improve material flow within the NSC,
- Maximize the use and productivity of part time and reserve personnel,
- Advance toward running the NSC like a commercial facility. [Ref. 9:pp. 3-4]

A study of material flow into, within, and out of the supply center is then conducted, taking into consideration:

- use of warehouse and support spaces,
- types and configuration of storage facilities,
- the need for additional storage aids,
- material requiring special storage and handling,
- activities involving information flow,
- level and pace of material flow activity,
- use of material handling equipment and systems, and
- the degree of space utilization. [Ref. 6:p. 28]

Although the Task A study is undertaken with the goal of maximizing the use of facilities and spaces, and minimizing the movement of material, the objective is to produce a baseline "as-is" rendering of existing material flow conditions on which recommendations and improvement methods may be based. This is accomplished by observing, measuring and documenting actual conditions out on the warehouse floor.

Exhibits 2-1, 2-2, and 2-3 are examples of "from-to" and "material flow" charts which were used by the contractor at NSC Pensacola to document the daily mean number of material moves between various warehouse locations during the receive-store-pick-ship cycle measured over the span of an observed business day. [Ref. 9]

Exhibit 2-1 shows the quantity, distance, and locations from and to which material moves.

FLOW IN				FLOW OUT			
Material Description	Qty. PL/Day	Distance Ft.	From/Via	To/Via	Qty. PL/Day	Distance Ft.	Material Description
Small Bin	5	475'	7816 to staging at J, then to N stage, FT the stow	Stage in N, then to 781-6 local del. FT.	3	500'	Small Bin Ite
Small Bin	8	325'	7816 to staging at J, then to I stage FT then stow	Stage in H, then to 3467 FT	2	900'	Small Bin Ite
Small Bin				Stage in I, then to 781-G local del. FT	5	400'	Small Bin Ite
Small Bin				Stage in J, then to 3467 FT	2	100'	Small Bin Ite
Semi-Bulk & Bin	3	175'	7816 to staging at J, to stow FT	Stage in J, then to 781-6 local del. FT	6	150'	NARF A and Sh Life
Repaired NARF	7	150'	781 I (NARF pack) FT	Stage in J, to muletrain for delivery to 3467	7	550'	NARF A and Sh Life
Bulk	15	625'	781-6 to stage in J, to stage in L, then stow FT	Stage in K, then to 781-6 local del. FT to 3467	15	350'	Bulk Items
				Muletrain	14	800'	Bulk Items
Bulk	12	700'	781-6 to stage in J, to stage in L, then to stow in L	781-6 local del. FT	10	500'	Bulk Items
Bulk			FT	3467	10	950'	Bulk Items
Bulk	6	350'	781-6 to stage to J, to stage at N, to	781-6 local del. muletrain	9	750'	Bulk Items
NARF A	6	450'	226 FT	3467 muletrain	27	750'	Bulk Items
Bulk	4	375'	781-I FT	781-6 local del. FT	1	475'	Bulk Items

Exhibit 2-1 "Flow In/Flow Out" Chart

Exhibit 2-2 shows the number of pallets moved per day from storage and receiving to issuing and storage.

FROM - TO CHART

Plant NSC-P Project ____ By ____ With ____ Date ____ Page ____ of ____

Item(s) Charted Goods on Pallets

Basis of Values Issues-Pallets/Day

FROM Activity or Operation \ TO Activity or Operation		1 467 Pack	2 Outbound Docks 781-C	3 Servmart	4 NARF Staging at 781-D	5 Stage for NARF at 740	6 226 Pack	7 P/U at Yard (Walk-thru)	8 685 Stage for Off-sta P/U	9 685 Stage for On-sta P/U	10 445 Stage for On-sta P/U	11 684 Stage for Del to NARF	12 3380 Stage for Del to NARF	13	14	15	16	17	18	19	20	TOTALS
751-H Bin	1	2	3																			5
781-I Bin	2	2	5																			7
751-J	3	6	7																			13
781-K	4	14	15																			29
751-L	5	10	10																			20
781-M	6	27	9																			36
751-A	7	3	20	10																		33
781-B (caged)	8	16	17																			33
791-B	9	3	3																			[illegible]
781-C	10	6	6																			12
781-D	11	1			5																	6
781-E	12	1			5																	6
781-F	13	1			5																	6
7?0	14					15																15
781-H (caged)	15		2				1															3
Yard Open-Stor'6	16	1	1					6														8
685-S	17								14	20												34
445	18										8											8
684	19	1					4					22										27
3380	20	1					2						12									15
TOTALS		95	98	10	15	15	7	6	14	20	8	22	12									[illegible]

NOTES

Exhibit 2-2 "From-to" Chart

Exhibit 2-3 depicts a warehouse floor layout to show the distance and direction of travel with which material receipts move.

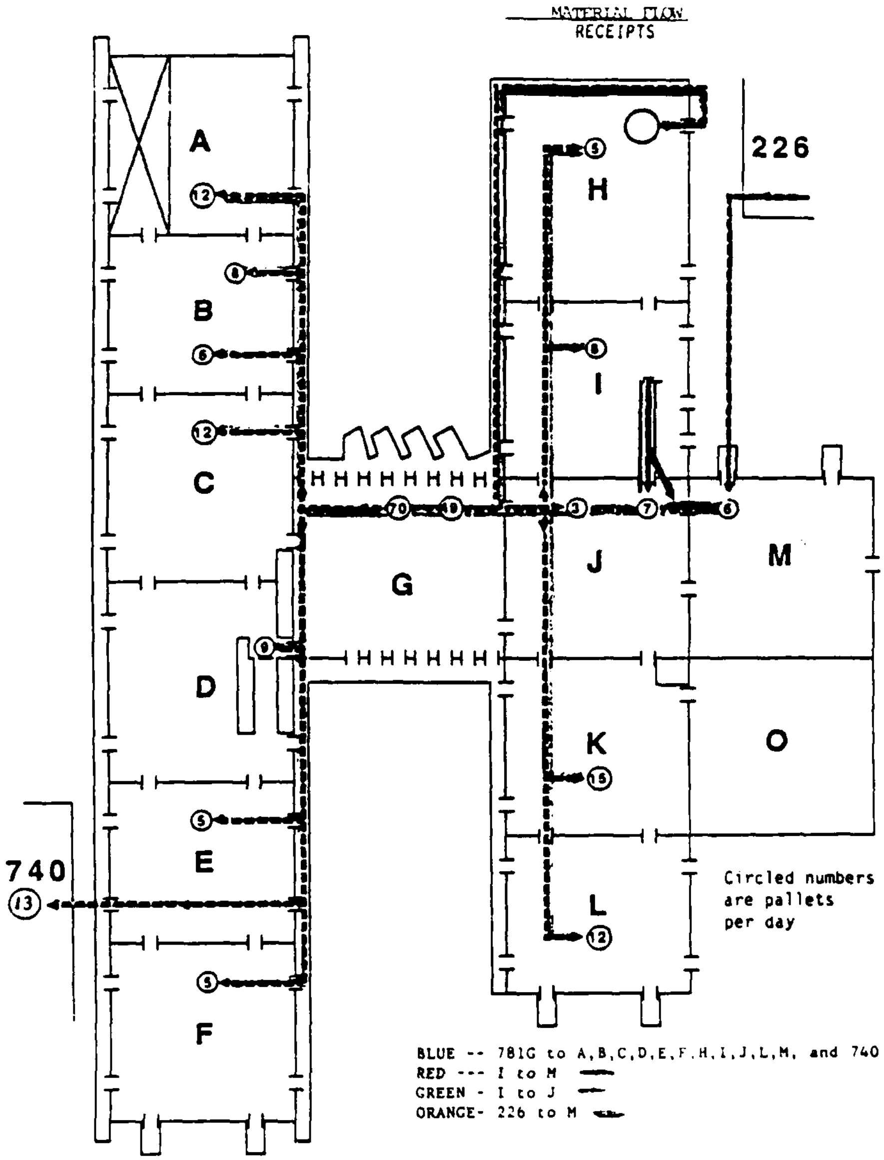

Exhibit 2-3 Material Flow Chart (Receipts)

Exhibits 2-4 and 2-5 are examples of NSC Pensacola storage analysis and warehouse usage charts which help determine ways to achieve storage and warehouse space efficiency.

Company NSC PENSACOLA Date 12/8 ______ Raw Materials ______ In-Process Goods

Prepared by PGH Sheet ______ Of ______ ______ Plant Supplies ______ Finished Goods

Description	Unit Loads				Quantity of Unit Loads Stored			Storage Space			
	Type	Capacity	Size	Weight	Maximum	Average	Planned	Method	Specifications	Area (sq. ft.)	Ceiling Height req'd
SONOBOUYS	CONT	25 EA	1 M/T	1250	150	60	100	BLOCK BULK	2 HIGH STACK	880	10'

Exhibit 2-4 Storage Analysis Chart

Other charts used by the EWP team to facilitate the data gathering process (but not presented) include:

- layout charts which depict the "as-is" layout of warehouse storage showing existing aisle space, wall and column locations, bulk storage, and office locations,

- storage rack usage potential charts which show the additional cube and storage capacity that can be obtained by using narrow aisles and stacking material four pallets high as opposed to three pallets high,

- flow process charts which describe the detailed actions involved in a particular process,

			RACK SPACE		OFFICE, ETC		AISLE SPACE		PALLET ON FLOOR	% ON FLOOR
WAREHOUSE	DESCRIP	GROSS SQ FT	SQ FT	%	SQ FT	%	SQ FT	%		
781 H	BIN	28000	8291	29.6	3500	12.5	15309	54.7	500	1.8
781 I	BIN	24000	5356	22.3	4400	18.3	14244	62.3	0	
781 J	BIN	40000	9954	24.9	5125	12.8	24921	62.3	0	
SUBTOTAL		92000	23601	25.7	13025	14.1	54474	59.2	500	

Exhibit 2-5 Warehouse Usage Chart

- flow diagrams which physically depict the sequence of material flow, and
- activity relationship charts which show the relationship between steps in a material flow process, the importance and reasons for steps to occur close to each other. [Ref. 10:pp. 28-56]

c. Analyzing the Data

Analyzing the data is the process of studying the information obtained through the material flow investigation (the measurements, charts, layouts, diagrams, and graphs), within the context of the principles of materials handling, to recognize opportunities for process improvement. Areas that have potential for significant payback, with only a moderate investment, are particularly desired. The analytic approach taken by the EWP team is a

comprehensive investigation to determine why things are done the way they are. By interviewing appropriate personnel and studying the material flow processes reflected on data charts and graphs, extra steps and unnecessary delays are often identified.

Two materials handling principles with which the EWP team would be particularly concerned are the:

- Systems principle: Integrate those handling and storage activities which are economically viable into a coordinated system of operation including receiving, inspection, storage, production, assembly, packaging, warehousing, shipping and transportation, and the

- Simplification principle: Simplify handling by eliminating, reducing, or combining unnecessary movements and/or equipment. [Ref. 11:p. 12][2]

Analyzing the activity for improvement involves understanding the current operation in terms of what is done, how it is done, why it is done, and how much is done. The kind of data analyzed is carefully selected through a modeling process which tests the relevance of the data to the measurement of work processes. A reference model developed for use at NSC Pensacola includes seven steps:

- Understand activity mission, tasks, and functions,

- Identify the key data which determines task work content,

- Determine current workplace work standards,

- Gauge work standards' improvement potential,

- Model the best practical current situation,

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[2] A complete listing of the twenty principles of materials handling is provided in Appendix A.

- Devise alternatives,
- Model and select alternatives. [Ref. 9:p. 8]

Key data areas subject to analysis at NSC Pensacola included:

- Work methods and procedures used to accomplish the tasks specific for each area of a warehouse,
- Defining workload information for each operating location and workstation,
- Activity times required to accomplish a task,
- Material flow patterns for various classes of supplies and customers,
- Receiving volumes according to transportation mode, packaging conditions and time required to prepare for warehousing,
- Classes of customers and order processing volumes for each customer class, and
- Warehousing costs in terms of facilities, operating costs and labor costs. [Ref. 9:pp. 12-13]

The following industry standards and measures were applied to key data during the analysis: [Ref. 9:pp. 9-10]

- Rack dimensions,
- Aisle widths,
- The extent of pallet use,
- Speed of movement for hi-rise picker,
- Unloading times (per load, line item, pallet, case),
- Stow times (per line item, per pallet),
- Replenishment times,
- Sorting times (per line item, per order),
- Picking times (per line item, pallet, order),

- Packing times (per parcel, line item, case),
- Dispatch times (per dispatched pack, per load).

d. Formulating and Evaluating Alternatives

Formulating and evaluating alternatives is the procedure by which the EWP team transforms the analyzed data into recommendations for action that are consistent with achieving maximum savings in the minimum amount of time and with the minimum cost to implement. The alternatives should reflect the judicious application of the materials handling principles. In addition to considering technical and economic factors, system relationships are considered to preclude trading off improvements in one functional area for problems in another. For example, adding a manual conveyor system to increase the flow of material from storage to a packing activity may create an unanticipated packing backlog unless the additional workload is accommodated.

Focusing on productivity as a reference point (measured as the ratio of output to input), basic industry measures and ratios are applied to show how efficiently resources are being used to generate work, products, or levels of service. By evaluating the alternatives using accepted ratios and measures, the relative worth of each of the alternatives is ascertained. [Ref. 10:pp. 58-60] The Materials Handling Handbook states:

> Materials handling is increasingly being recognized as a primary tool for improving productivity. Thus, any evaluation of alternative materials handling plans must

consider how each approach will affect the productivity of the facility or operation it is intended to serve.

The basic measure of productivity is the ratio of output to input. The ratio can be expressed in terms such as number of damaged loads per total number of loads, cases packed per labor hour, items stored per square foot, and so on. Such ratios are used to show how efficiently resources are being used to generate work, products, or levels of service. They provide a measuring stick of relative performance.

The primary value, then, of these ratios lies in their use for monitoring performance over time. Comparisons can be made against ratios achieved during past periods. Trends or changes in productivity measures can be used to evaluate performance of a system, and point to the need for corrective action where appropriate. [Ref. 11:p. 6]

Ratios applied toward materials handling process evaluation which reflect measurements taken during daily periods of observation (over several months) include:

- (MHL) Material Handling Labor ratio =

$$\frac{\text{Personnel assigned to MH Duties}}{\text{Total Operating Personnel}}$$ [3]

- (DLMH) Direct Labor Material Handling ratio =

$$\frac{\text{MH Time Spent by Direct Labor}}{\text{Total Direct Labor Time}}$$

- (EU) Equipment Utilization Output ratio =

$$\frac{\text{Actual Hours Equipment Used}}{\text{Total Time Available For Use}}$$ [4]

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[3]Total Operating Personnel equates to the total number of personnel employed in a particular physical distribution functional area like receiving, packing and crating, etc.

[4]Total Time Available For Use equates to the time, during the period of observation, that materials handling equipment is available to be used and not unavailable for any reason (down for maintenance, repair, etc.).

- (SSUE) Storage Space Utilization Efficiency =

$$\frac{\text{Storage Space Usefully Occupied}}{\text{Net Usable Space}}$$

- (ASP) Aisle Space Percentage =

$$\frac{\text{Space Occupied By Aisles}}{\text{Total Space}}$$

- Receiving (Shipping) Productivity ratio =

$$\frac{\text{Weight Received (Shipped) Per Day}}{\text{Labor Hours Per Day}}$$

- (TPI) Throughput Performance Index =

$$\frac{\text{Actual Throughput Per Day}}{\text{Daily Throughput Capacity}}$$ [5]

- Warehousing Cost Per Unit Of Throughput =

$$\frac{\text{Total Warehousing Cost}}{\text{Total Throughput Units}}$$

- Transportation Cost Per Unit Transported =

$$\frac{\text{Total Transportation Cost}}{\text{Total Volume Of Orders Processed}}$$

- Order Processing Cost Per Unit Of Order =

$$\frac{\text{Total Order Processing Cost}}{\text{Total Volume Of Orders Processed}}$$

In addition to the above objective ratios of relative worth, subjective/intangible measures are considered in evaluating alternatives. The relative importance (on a low to high scale of one to ten) of factors such as morale, customer service, labor skill

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[5]Daily Throughput Capacity is a measure of the number of line items which could be moved to or from storage per day based upon scheduled workload.

compatibility[6], and workforce flexibility[7], are applied against each optional alternative to get importance values for comparison. [Ref. 10:pp. 61-63]

e. Choosing the Solution

Choosing the solution from among the measured alternatives is the culmination of the material flow analysis. This is done by top management action and is supported by the thorough testing of the different productivity improvement approaches. Techniques commonly used in testing alternatives include:

- Mathematical simulation,
- Queuing analysis,
- Location analysis,
- Optimization (including linear and dynamic programming), and
- Economic analysis.

The first four of the above testing techniques help identify those alternatives which are technically feasible. Economic analysis compares the technically feasible alternatives against economic criteria (such as payback period, return on investment, and present value of future cash flows) to rank the solutions according to cost. [Ref. 10:pp. 65-68]

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[6]Whether the skills possessed by the labor force in the targeted function are suitable to perform an alternative work process.

[7]Whether the workforce is willing to learn the skills necessary to perform an alternative work process.

An example of an economically feasible alternative for the Packing/Shipping area at NSC Pensacola resulting from the material flow analysis is shown in Exhibit 2-6. [Ref. 10:p. 86]

f. Implementing Recommendations

Implementing recommendations chosen by top management from the material flow analysis is the crux of EWP Task A. Since selected recommendations may run the gamut from obtaining labor saving devices to changing work methods and facilities, the success of the implementation depends on the planning, coordination, and follow-up by the EWP team. Success also depends critically on the commitment and concerted effort of the people in the targeted functions. A rapid successful changeover to the Task A recommended way of doing business is the foundation for the next step in the EWP process, the development of engineered performance standards in Task B.

g. Establishing Engineered Performance Standards

Establishing engineered performance standards is the process of determining what the quality, quantity, and timeliness of work should be for a discrete productive work task, given that the task is performed by a worker who possesses the necessary skills, tools, and training to accomplish it safely and at an acceptable level of quality. Under EWP, once the workplace is reorganized to facilitate material flow in Task A, employee performance standards are

IV. OTHER

RECOMMENDATION

IV.7 Substitute lift trucks for mule trains and substitute hand lift trucks for conventional lifts and trucks.

SUMMARY OF SAVINGS

Cost = $0	Cost Avoid. = $0
Savings = $61,620	Pay Back Period: Immediate

AS-IS CONDITION

Currently at building 781, 294 pallet equivalents are shipped each day. This represents an average of one every 1.6 minutes. This volume of material being moved each day does not warrant the use of the types of MHE currently being employed.

DISCUSSION

The quantities of material being moved at building 781 do not dictate the use of mule trains or the roller conveyor to move material from receiving to stow, nor from pick to delivery/ shipping. The use of conventional fork lift trucks, and power assisted hand pallet trucks (or walkies or ride-on trucks) has been assumed. These fork lift trucks or power assisted pallet trucks, rather than mule trains should be used. This is possible because by relocating packing to 781-G, material does not have to travel as far to stow and from pick to delivery. The use of powered hand pallet trucks and conventional lift trucks to pick and conventional trucks to move material to 781-G for delivery is recommended.

COST JUSTIFICATION

We now have 4.16 trucks in receipts + 24 in storage + 7.3 trucks in dispatch. Picking is normally done direct onto a pallet on a power assisted ride-on truck. As these trucks become due for replacement, 6 trucks could be converted to pedestrian trucks. The capital cost savings would be: Cost of 2,000 lb. lift truck = $15,670; cost of powered hand pallet truck = $5,400.

2 X ($15,670 - $5,400) = $61,620.

Exhibit 2-6 Material Flow Analysis Recommendation

developed using the Maynard Operation Sequence Technique (MOST).

MOST is a system which measures work, specifically the work that is performed when an object is moved. Based on the classical definition of work being the product of force times distance, and on the understanding that objects may be moved by either picking them up and moving them freely through space or by moving them while maintaining contact with another surface, MOST measures combined sequences of basic motions (called activities) which are required to move objects certain distances to accomplish work.

MOST identifies the combined sequences of basic motions required to move objects by separating the combined sequences into specific groups (called move sequences) based upon how objects are moved. This allows the analyst to measure combined motions which accomplish work in logical sequence. The three move sequences which describe manual work within the basic MOST technique include:

- The General Move Sequence (for the spatial movement of an object freely through the air),

- The Controlled Move Sequence (for the movement of an object when it remains in contact with a surface or is attached to another object during the movement),

- The Tool Use/Equipment Use Move Sequence (for the use of common hand tools and office equipment).

Additional move sequences describe work when equipment is integrated into the effort to move objects:

- Move With Powered Crane (Jib type),
- Move With Powered Crane (Bridge type),
- Move With Truck.

To actually measure a work task (which is a series of move sequences), MOST uses a shorthand notation called the fully indexed sequence model. The fully indexed sequence model is an arrangement of the individual actions (called subactivities) required to complete a work task in the order in which they occur. The model is comprised of time-related index numbers subscripted to an arrangement of subactivities (which are shown as alpha characters). For example, a fully indexed General Move sequence might be written:

$$A_6 \quad B_6 \quad G_1 \quad A_1 \quad B_0 \quad P_3 \quad A_0$$

where:

A_6 = Walk three to four steps to object location,

B_6 = Bend and arise,

G_1 = Gain control of one light object,

A_1 = Move object a distance within reach,

B_0 = No body motion.

P_3 = Place and adjust object,

A_0 = No return.

The above example could represent the action required to walk three steps to pick up a bolt from floor level, arise, and place the bolt in a hole. Even though there is no time associated with two of the actions in the sequence above, they are still annotated to complete the General Move sequence and are assigned index numbers of zero, a practice which is consistent throughout MOST work measurement.

The time units used in MOST are called time measurement units (TMU). One TMU equates to .00001 hours, or .0006 minutes, or .036 seconds. Conversely, one hour equals 100,000 TMU, one minute equals 1,667 TMU and one second equals 27.8 TMU. The time value in TMU for each manual sequence model is calculated by adding the index numbers and multiplying the sum by ten. In the above General Move sequence example, the time would be (6 + 6 + 1 + 1 + 0 + 3 + 0) times ten = 170 TMU, corresponding to 0.1 minute or 5.92 seconds. All time values established by MOST reflect an average skilled operator's speed at an average safe pace, referred to as the 100% performance level. The Powered Crane and Truck sequences convert index numbers to TMU using a multiplier of 100. [Ref. 12:pp. 4-9]

Subactivities associated with the General Move sequence include:

- A = Action distance (mainly horizontal),
- B = Body motion (mainly vertical),

- G = Gain control,
- P = Place.

Additional subactivities used in describing the Controlled Move sequence include:

- M = Move controlled,
- X = Process time,
- I = Align.

In addition to the above, the following subactivities are used in describing the Tool Use/Equipment Use sequence:

- F = Fasten,
- L = Loosen,
- C = Cut,
- S = Surface treat,
- R = Record,
- T = Inspect, Think, or Read,
- M = Measure. [Ref. 12:p. 6]

The following additional subactivities are used when MOST is measuring work in a clerical function:

- W = Typewrite,
- K = Calculate,
- H = Paper handling operation. [Ref. 13]

Exhibits 2-7 and 2-8 show indexed subactivity matrices for General Move and Controlled Move sequences. The matrices contain the descriptions of subactivities pertaining to each move sequence, and associated time-related index numbers and clock times for each subactivity/time-related index number

GENERAL MOVE

ABGABPA					
Index	A	B	G	P	Index
	Action Distance	Body Motion	Gain Control	Place	
0	≤ 2 [illegible] ≤ 5 [illegible]			Hold Toss	0
1	Within Reach		Light Object Light Objects Simo	Lay Aside Loose Fit	1
3	1 2 Steps	Bend And Arise 50% Occ	Non Simo Heavy or Bulky Blind or Obstructed Disengage Interlocked Collect	Adjustments Light Pressure Double	3
6	3 4 Steps	Bend And Arise		Care or Precision Heavy Pressure Blind or Obstructed Intermediate Moves	6
10	5 7 Steps	Sit Or Stand			10
16	8 10 Steps	Through Door Climb On or Off			16

Exhibit 2-7 General Move Matrix [Ref. 13]

CONTROLLED MOVE

ABGMXIA							
Index	M		X			I	Index
	Move Controlled		Process Time			Align	
	Push/Pull/Pivot	Crank (Revs)	Seconds	Minutes	Hours	Object	
1	≤ 12 Inches (30 cm) Button/Switch/Knob		.5	.01	.0001	To One Point	1
3	> 12 Inches (30 cm) Resistance Seat or Unseat High Control 2 Stages ≤ 12 Inches (30 cm)	1	1,5	.02	.0004	To Two Points ≤ 4 Inches (10 cm)	3
6	2 Stages > 12 Inches (30 cm)	3	2,5	.04	.0007	To Two Points > 4 Inches (10 cm)	6
10	3 4 Stages	6	4,5	.0[illegible]	.0012		10
16		[illegible]	[illegible]	[illegible]	.0019	Precision	16

Exhibit 2-8 Controlled Move Matrix [Ref. 13]

combination. Indexed subactivity matrices are used by MOST analysts as a guide when measuring work. Subactivities used to describe manual and powered equipment handling of objects include:

- A = Action distance,
- T = Transport,
- K = Hook up and Unhook,
- F = Free object,
- V = Vertical move,
- L = Loaded move,
- P = Place,
- S = Start and Park. [Ref. 12:p. 10]

MOST index values are all, therefore, predetermined and available to an analyst for reference when evaluating the length of time required to perform a move sequence. When analyzing an operation, MOST analysts focus on subactivities with an index value of six or greater in an effort to detect whether a methods improvement, a layout change, or a procedural change might be indicated. [Ref. 12:p. 14]

In EWP Task B, MOST is an iterative process used to develop initial performance standards. It is also a continuous process used to develop revised standards after work improvements have been made.

When performance standards are implemented in a work area, a system is established to record, chart, and

evaluate the measurement of work performed. This is done in EWP within the statistical process control requirement of Task B and is called the EWP Support System (EWPSS). It is based on a daily report of each employee's recorded amount of time actually at work and inlcudes the amount of time the employee is actually at work but not doing a job (called work delay), and standard hours earned. Standard hours earned is the amount of time which all productive tasks performed during a given workday should have consumed, based on the volume of work accomplished and the applicable engineered performance standard. After receiving the input from the employee, level one supervisors check the data for accuracy and use EWPSS to calculate the percentages for performance and productivity earned by each employee, and the utilization percentages earned by the supervisor. The supervisor also annotates the number of daily work process quality checks and quality deficiencies associated with each worker. The end result becomes the Level 1 Performance & Production Report shown in Exhibit 2-9. This report serves as a feedback, performance control, and usage planning mechanism for use by level 1 supervisors. [Ref. 14]

Key performance indicators included in the EWPSS Level 1 Performance & Production Report and their methods of calculation are:[Ref. 14]

- Performance = $\dfrac{\text{Standard Hours Earned}}{\text{Actual Hours Worked--Delay Time}}$

INDIV	ACTUAL AVAIL	TIME DELAY	STD HRS EARNED	% PERF	% UTIL	% PROD	CHKS	DEF
JBB	8.0	0.5	4.9	65.3%	93.8%	61.3%	5	0
ADA	8.0	0.2	4.2	53.8%	97.5%	52.5%	5	0
FSB	8.0	1.4	2.5	37.9%	82.5%	31.3%	5	0
YWA	8.0	0.0	7.8	97.5%	100.0%	97.5%	5	1
FAA	8.0	0.5	8.3	110.7%	93.8%	103.8%	7	0
COS	8.0	0.0	6.1	76.3%	100.0%	76.3%	5	1
KIH	8.0	0.7	5.8	79.5%	91.3%	72.5%	5	0
JDE	6.0	2.2	3.4	89.5%	63.3%	56.7%	5	0
RMM	4.0	0.4	3.0	83.3%	90.0%	75.0%	1	0
JMF	4.0	0.3	3.1	83.8%	92.5%	77.5%	1	0
TOTAL	70.0	6.2	49.1	77.0%	91.1%	70.1%	44	2

Exhibit 2-9 Level 1 Performance & Production Report

- Utilization = $\dfrac{\text{Actual Hours Worked--Delay Time}}{\text{Actual Hours Worked}}$

- Productivity = $\dfrac{\text{Standard Hours Earned}}{\text{Actual Hours Worked}}$

  = Performance times Utilization

The aggregated statistics from the Level 1 Performance & Production Report are used to produce the Level 2 Performance & Production Report as shown in Exhibit 2-10 to show higher echelon management how different work areas, and their level one supervisors compare. [Ref. 14]

The weekly Level 1 Delays Report, shown in Exhibit 2-11, is produced using information from the Level 1 Performance & Production Report and provides the reasons for work delays.

AREA	ACTUAL AVAIL	TIME DELAY	STD HRS EARNED	% PERF	% UTIL	% PROD	CHKS	DEF
P1	40.0	1.5	44.9	65.3%	93.8%	61.3%	25	3
P2	20.0	2.2	44.2	53.8%	97.5%	52.5%	15	7
P3	32.0	1.4	42.5	37.9%	82.5%	31.3%	20	0
P4	48.0	0.0	47.8	97.5%	100.0%	97.5%	10	1
ST1	56.0	0.5	48.3	110.7%	93.8%	103.8%	17	0
DRY	40.0	4.0	46.1	76.3%	100.0%	76.3%	15	6
HA[illegible]	48.0	8.7	45.8	79.5%	91.3%	72.5%	17	0
IS2	24.0	2.2	43.4	89.5%	63.3%	56.7%	35	4
TOTAL	208.0	[illegible]	49.1	77.0%	91.1%	70.1%	154	21

Exhibit 2-10 Level 2 Performance & Production Report

LEVEL 1 DELAYS REPORT

SUPERVISOR: DATE:
WORK AREA:

DELAY TYPE	DAY HOURS	WEEK HOURS	MONTH HOURS
MEETINGS	10	47	472
EQUIP FAILURE	1	5	17
OUT OF WORK	4	19	69
RE-DO	2	9	34
OBTAIN MATLS	3	14	52
OTHER	0	13	48
TOTAL DELAYS	20	107	692

Exhibit 2-11 Level 1 Delays Report [Ref. 14]

The Task B EWPSS reports are generated from a micro/minicomputer based dBase III program. Additional output in the way of charts and graphs may be obtained.

h. The EWP Productivity Enhancement System

The EWP Productivity Enhancement System is developed under Task C of the EWP contract. This productivity enhancement system encompasses EWPSS and is a micro/minicomputer based decision support system for middle and upper management. It provides aggregated statistics on productivity, performance, and utilization in tabular, chart, or graphic format to facilitate planning and decision making. It combines information from the level 1 and level 2 EWPSS reports to display monthly, quarterly, and yearly summaries. [Ref. 6]

B. SUMMARY

The first part of this chapter explains how and why the Engineering the Workplace project was developed. This was followed by a detailed description of the application of EWP to the physical distribution function in a Navy supply center. A discussion of the pertinent features of the major tasks of EWP was then provided. By offering such a detailed explanation of the EWP process, it is hoped that the reader will gain an understanding of the methodology and appreciate the complexities and relationships of the various actions within the EWP application procedure.

III. DATA PRESENTATION

A. INTRODUCTION

This chapter describes the status of the Engineering the Workplace (EWP) project at NSC Pensacola, NSC Jacksonville, and NSC Oakland and presents selected information obtained from each activity in a manner to provide the reader with:

- an appreciation for the size, scope of business, and mission of each activity,
- a qualitative and quantitive understanding of the performance measures and projected resource savings associated with implementing EWP at each activity.

The information obtained from NSC Pensacola includes data describing the capabilities, the workload, the personnel and funding resources, material flow improvements, and actual worker productivity for selected work groups within the Physical Distribution Department. The information obtained from NSCs Jacksonville and Oakland includes data describing the capabilities, the workload, the personnel and funding resources, and material flow improvements. Productivity data is not included, however, because Task B performance reporting had not yet been implemented at NSCs Jacksonville and Oakland.

B. ENGINEERING THE WORKPLACE (EWP) AT NSC PENSACOLA

1. Activity Overview

NSC Pensacola is the newest and smallest of the NAVSUP stock points responsible for providing wholesale and retail level supply support for various DOD activities throughout the Gulf and southeastern states, an area of responsibility extending from western Florida to Louisiana and Tennessee. [Ref. 15:pp. 2-4]

2. Activity Workload and Resource Indicators

Exhibit 3-1 displays NSC Pensacola workload indicators, personnel resources, and funding resources for the fiscal years 1986[8], 1987, and 1988 (through 30 April 1988). The workload indicators shown represent monthly averages. Line items carried measures the average monthly range of items carried in stock. Demands and issues measure the monthly average number of units requested by and issued to customers, respectively. Receipts measures the volume of receipts processed reflected from single and multiple line item receipt documents (counting each document as a receipt processed). NRFI inductions measures the average monthly number of depot level repairable (DLR) items transferred to the Naval Aviation Depot Pensacola for rework, while RFI returns measures the average monthly number of reworked DLR

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[8]NAVSUP became major claimant in 1986 when NSC Pensacola was commissioned a Naval Supply Center. Previously, as NAS Pensacola Supply Department, the Chief of Naval Education and Training (CNET) had claimant responsibility.

FISCAL YEAR	1986	1987	1988
LINE ITEMS CARRIED	89,809	99,912	105,832
DEMANDS	28,925	28,865	34,254
ISSUES	25,693	25,982	27,102
RECEIPTS	11,418	11,380	11,788
NRFI INDUCTIONS	5,143	4,376	4,367
RFI RETURNS	5,033	4,379	4,078
PERSONNEL	415	401	387
FUNDING ($M)	15.729	16.782	16.182

Exhibit 3-1 Workload, Personnel, and Funding

items transferred to the Naval Aviation Depot Pensacola for rework, while RFI returns measures the average monthly number of reworked DLR items returned to NSC Pensacola for stock. Funding and personnel figures are end of fiscal year totals.[9] [Ref. 16]

3. Facilities

NSC Pensacola is located on the Naval Air Station (NAS) Pensacola and comprises eight buildings with approximately 749,000 square feet of covered storage space. The NSC buildings are outfitted with storage aids that afford 19,533 pallet positions, 83,894 bin locations, and

[9]Activity workload and resource indicator units of measure for NSCs Jacksonville and Oakland are consistent with those described for NSC Pensacola except as noted.

9,748 bulk pallet floor locations. Open yard storage space totals 16,731 square feet, and refrigerated space totals 14,000 square feet. Over 90 percent of all non-perishable and non-hazardous material is received from, stored, picked, and shipped from one 571,000 square foot single story building. [Ref. 9:p. 58]

4. Material Flow Improvements

Recommendations to improve the flow of material at NSC Pensacola were a product of the material flow analysis and consisted of cost and technical analyses grouped into the following functional categories:

- Receiving,
- Stow/Pick,
- Packing/Shipping,
- Other Recommendations.

Examples of material flow analysis recommendations which project significant savings and short term payback are shown in Exhibits 3-2 and 3-3. A summary of material flow analysis recommendations made at NSC Pensacola is provided in Appendix B. [Ref. 9:pp. 59-66]

5. Performance Data

Daily employee productivity totals from the Receiving and Traffic Divisions of the NSC Pensacola Physical Distribution Department were used from the Level 1 Performance & Production Reports (an example of which has been shown in Exhibit 2-9) to determine the trend of worker

I. RECEIVING

RECOMMENDATION

I.2 Install roller conveyors to assist off loading of non-palletized loads

SUMMARY OF SAVINGS

Cost = $31,000	Cost Avoid. = $0
Savings = $21,733	Pay Back Period: 1½ years

AS-IS CONDITION

As part of the UADPS improvement with ABE, terminals are to be installed to allow first the checking against the receipt due file, and second the on line display of stowing instructions. The use of power driven roller conveyors can be installed to improve the productivity of non-palletized loads.

DISCUSSION

The use of power driven roller conveyors can be used to present material to the ABE terminals in an orderly fashion, and stage according to the final destination as the conveyor is off loaded.

COST JUSTIFICATION

At the present time 6 warehousemen spend 15% of their time moving material to the floor from the ramp. Two conveyors would eliminate this operation. Savings are .9 x $24,148 = $21,733.

Exhibit 3-2 Material Flow Analysis Recommendation

III. PACK/SHIP

RECOMMENDATION

III.4 Move packing and shipping to building 781-G and close down 3467 or use it for another purpose.

SUMMARY OF SAVINGS

Cost = $63,000	Cost Avoid. = $80,000
Saving = $26,484	Pay Back Period: 2.3 years

AS-IS CONDITION:

The present location of packing is too far away from the main areas of activity. Requisitions must be separated for packing by local or off base delivery and each goes a different route. The packing/shipping floor is frequently congested because it is poorly laid out.

DISCUSSION

Efficiencies can be gained by moving packing and shipping to 781-G (see Receiving/Shopping Layout Block Diagram on next page) and to require the stock pickers to pick to pack utilizing the IRDF as a mailing label. This will eliminate a pack and stage operation and should speed up the entire process. With the economies realized from ABE there will be sufficient room to locate packing in 781-G and shorten travel distances.

COST JUSTIFICATION

The cost to move selected sections of conveyor and other weighing and wrapping equipment and clearing out 3467 is estimated at $63,000. Maintenance savings on equipment no longer used is estimated at $15,000. Space made available by moving to 781-G is 20,000 sq.ft. x $4/sq.ft. = $20,000. Additional savings realized by shortening travel distances to packing in 781-G are included in Recommendation II.5.

If 3467 is closed down empty then utility costs will be saved: $430,136 x 2.5% = $11,484. ($430,136 annual NSC utility cost; 3467 = 20,000 sq.ft. or 2.5% of NSC total)

Exhibit 3-3 Material Flow Analysis Recommendation

productivity over time. Productivity was chosen as the index on which to base an analysis rather than performance or utilization because productivity is a better measure of worker effectiveness over the total workday.

Productivity represents the ratio of hours earned according to an established set of engineered performance standards (standard hours earned) to the number of hours the employee was being paid to work. Performance is the ratio of standard hours earned per the number of hours the employee was engaged in work (a measure which excludes the time the employee was not engaged in work (delay time)). Utilization is the ratio of productivity to performance and measures how busy a level 1 supervisor keeps his work group (assuming that the supervisor has a certain amount of control over delay time).

The data obtained from the Receiving Division Level 1 Performance and Production Reports covers ten wage grade employees in the Receipt Processing Section for the period 2 December 1987 to 31 March 1988. Data from the Traffic Division Level 1 Performance and Production Reports covers twelve wage grade employees in Packing and Crating Section Two for the period 2 December 1987 to 31 March 1988.

5. <u>Presentation of Performance Data</u>

a. Receipt Processing Section

Personnel assigned to the Receipt Processing Section are responsible for the proper processing of

material received at NSC Pensacola. According to the NSC Pensacola functional description, the Receipt Processing Section is specifically required to:

> Receive, check, and inspect material received; segregate material by proper designation for ultimate movement to storage/customers, or for transshipment; maintain liaison and control over inbound cargo coming into the supply center; process receipt documentation for updating inventory control and financial management records under the UADPS-SP Supply Management Program concept; determine and provide consignee address on all incoming receipts for storage or for direct delivery to customers. [Ref. 15:p. 35]

Appendix C presents a table of actual employee productivity percentages obtained from the Receipt Processing Section Level 1 Performance and Production Reports for the period 2 December 1987 through 31 March 1988. Each productivity percentage in Appendix C represents the daily aggregate productivity for the ten worker Receipt Processing Section calculated from the daily productivity percentages reported by individual workers to their level 1 supervisor. Figure 3-1 is a graphic plot of the actual productivity percentages of the Receipt Processing Section for the period 2 December 1987 through 31 March 1988.

b. Packing and Crating Section Two

Personnel assigned to Packing and Crating Section Two are responsible for constructing and controlling containers for the protection of material. According to the NSC Pensacola functional description, Packing and Crating Section Two is specifically required to:

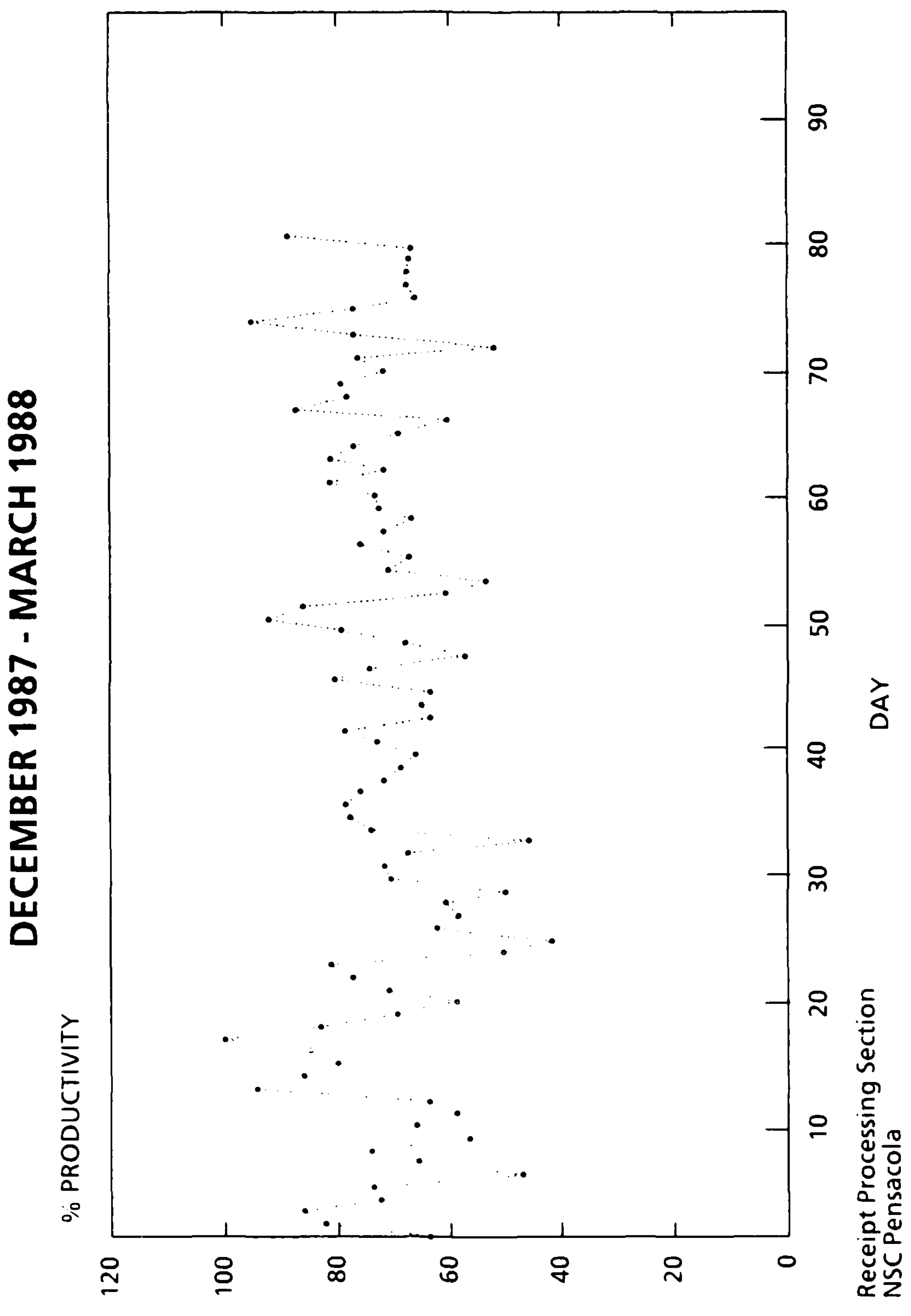

Figure 3-1 Receipt Processing Productivity

> Direct, receive, design and construct wooden, plywood, or metal structures of various sizes and complex design used to protect, support and secure material for shipments on carrier equipment; pack or crate and mark all material as required for domestic or overseas shipment or storage; construct boxes and crates as required for material manufactured or repaired by the Naval Aviation Depot; build essential storage aids when required; review reports of damaged or improper shipments initiated against the activity to determine and recommend corrective action. [Ref. 15:pp. 36-37]

Appendix D presents a table of actual employee productivity percentages obtained from the Packing and Crating Section Two Level 1 Performance and Production Reports for the period 2 December 1987 through 31 March 1988. Each productivity percentage in Appendix D represents the daily aggregate productivity for the 12 worker Packing and Crating Section Two calculated from the daily productivity percentages reported by individual workers to their level 1 supervisor. Figure 3-2 is a graphic plot of the actual productivity percentages of Packing and Crating Section Two for the period 2 December 1987 through 31 March 1988.

C. ENGINEERING THE WORKPLACE (EWP) AT NSC JACKSONVILLE

1. Activity Overview

NSC Jacksonville is a medium sized stock point which provides wholesale and retail level supply support to various DOD activities in the southeastern U.S. and limited support to various overseas commands. Major activities supported include the Naval Aviation Depot (NADEP) Jacksonville, Naval Air Stations (NASs) Cecil Field, Jacksonville

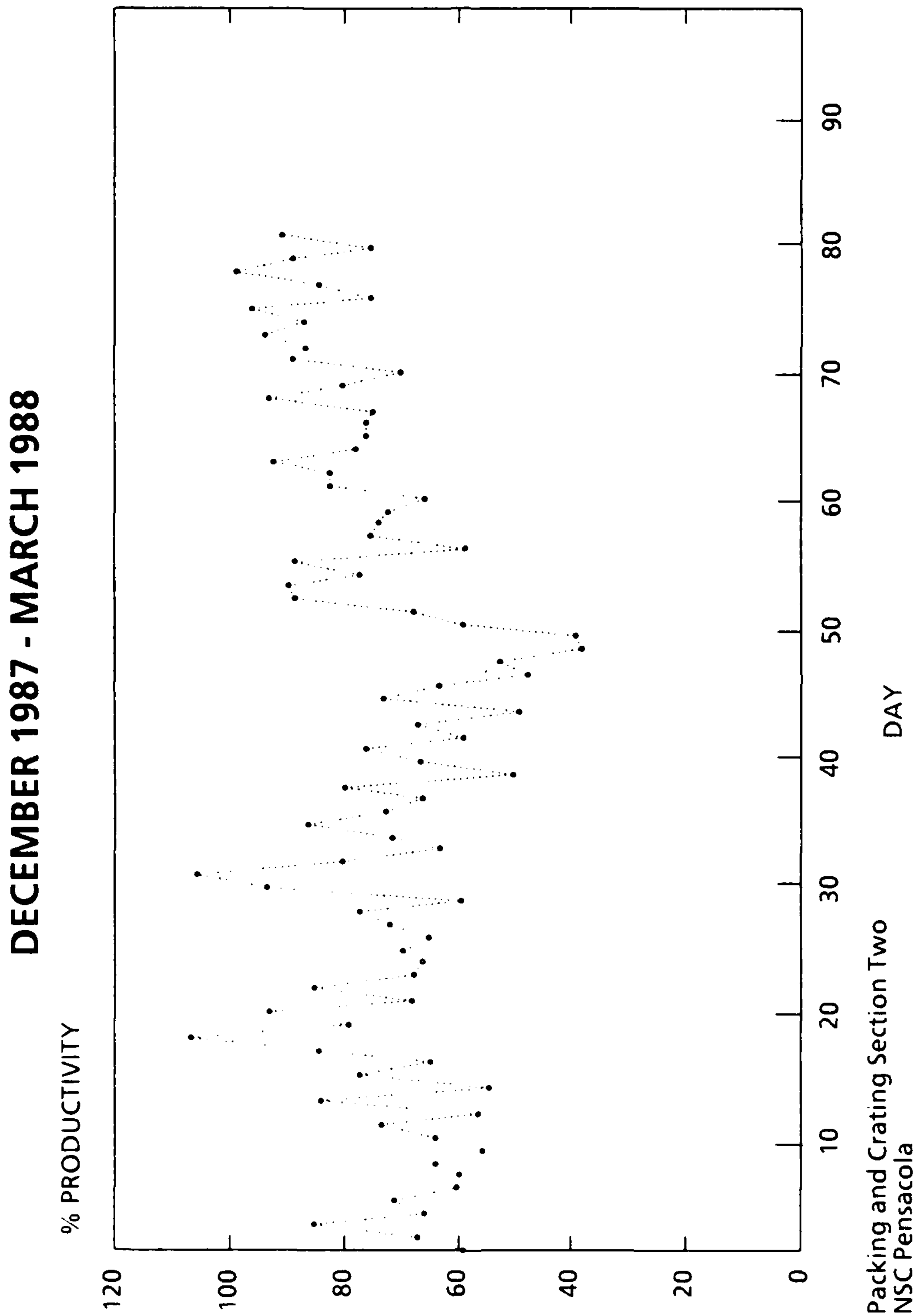

Figure 3-2 Packing and Crating Productivity

and Key West, Naval Stations Roosevelt Roads and Guantanamo Bay, Naval Station Mayport, and approximately 34 U.S. Navy ships homeported at Naval Station Mayport. [Ref. 17:p. 2]

The administrative and functional organizations at NSC Jacksonville are undergoing a complete transformation. Under a new "stovepipe" concept, activity personnel and funding resources are being realigned to reflect clear authority, accountability, and responsibility for the life-cycle management of specific material commodity categories. [Ref. 1]

2. Activity Workload and Resource Indicators

Exhibit 3-4 displays NSC Jacksonville workload indicators, personnel resources, and funding resources for the fiscal years 1986, 1987, and 1988 (through 30 April 1988). Workload indicator measurement descriptions in Exhibit 3-4 are identical to the ones used to describe NSC Pensacola workload indicator measurements in Exhibit 3-1. The workload indicators represent monthly averages, while the personnel and funding resources are end of fiscal year totals. [Ref. 18]

3. Facilities

NSC Jacksonville is located on the Naval Air Station (NAS) Jacksonville and comprises 16 buildings with approximately 1,077,000 square feet of covered storage space and 224,985 square feet of uncovered storage space. An additional 92,494 square feet of covered storage is located at

FISCAL YEAR	1986	1987	1988
LINE ITEMS CARRIED	206,453	225,872	228,964
DEMANDS	88,441	86,964	77,771
ISSUES	54,476	55,374	52,645
RECEIPTS	22,779	21,694	18,984
NRFI INDUCTIONS	4,357	4,233	3,849
RFI RETURNS	4,527	4,207	3,778
PERSONNEL	768	746	607
FUNDING ($M)	21.694	21.069	20.458[10]

Exhibit 3-4 Workload, Personnel, and Funding

the Fleet Support Center at Naval Station Mayport. [Ref. 17:p. 2]

The physical distribution function at NSC Jacksonville occurs at three separate sites. Two of the sites are located at NAS Jacksonville (the North Area and the South Area), and one site is located at Naval Station Mayport. The North Area is where most of the material consigned to the supply center is received, and where most of the line items are stored. The South Area is 2.5 miles from the North Area and stores bulk, hazardous, and

[10]Excludes $2.914M transferred from the Naval Air Systems Command to NAVSUP for the functional supply support of NADEP Jacksonville.

flammable material. The Fleet Support Center at Naval Station Mayport is approximately 40 miles away from NAS Jacksonville. [Ref. 17:p. 8] NSC Jacksonville is installing an intra-activity radio frequency communication system to enhance information flow and document processing.[11]

4. Material Flow Improvements

Recommendations to improve the flow of material at NSC Jacksonville were a product of a comprehensive Task A material flow analysis of the physical distribution function conducted at each of the support sites. The material flow analysis consisted of cost and technical analyses grouped into the following functional categories:

- Receiving,
- Stow/Pick,
- Packing/Shipping,
- Other Recommendations.

Examples of material flow analysis recommendations which project significant savings and short term payback are shown in Exhibits 3-5 and 3-6. A summary of material flow analysis recommendations made at NSC Jacksonville is provided in Appendix E. [Ref. 19:pp. 8-11]

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[11] Radio was selected over telephones and dedicated communication lines because of less cost and greater capability.

III.4 OTHER

RECOMMENDATION

III.4.8 Reduce manpower in FSC SERVMART by leveling the workload.

SUMMARY OF SAVINGS

Cost = $ 0
Savings = $38,314

Cost Avoidance = $ 0
Payback Period = Immediate

AS-IS CONDITION

The manpower level in the SERVMART is currently at thirteen employees. This is based on handling peak requirements. Both the volume of incoming material and the volume of sales are subject to wide fluctuations.

When examining daily records of incoming material volume, a totally random pattern emerges. For example, during a recent four week period (show in Exhibit 26 of the As-Is), the number of items received by SERVMART ranged from 150 to 18,805. The number of items received is the number of items input to the EPOS System.

By contrast, the level of sales is very patterned based on the day of the week. During the same four week period, the number of items sold per day of the week at SERVMART is:

SALES	MON	TUE	WED	THR	FRI
Avg	282	776	868	1023	511
Hi	432	864	1109	1169	706
Low	97	698	646	790	405

Peak sales occur on Tuesday, Wednesday and Thursday. Significantly lower sales occur on Monday and Friday.

Exhibit 3-5 Material Flow Analysis Recommendation

III.4 OTHER

RECOMMENDATION

III.4.7 Eliminate excessive Material Handling Equipment (MHE) from the Distribution Branch.

COSTS/SAVINGS/PAYBACK

Costs. There are no costs associated with this recommendation.

Cost Avoidance. Surplus mule train trailers result in cost avoidance (see III.4.6).

Savings. Savings from eliminating 1 warehouse tractor:

1 x $794/yr (maintenance)		= $ 794/yr

Savings from eliminating 2 forklifts:

2 x $1667/yr (maintenance)		= $3,334/yr
	Total	= $4,128/yr

Payback Period. Immediate

Exhibit 3-6 Material Flow Analysis Recommendation

D. ENGINEERING THE WORKPLACE (EWP) AT NSC OAKLAND

1. Activity Overview

NSC Oakland is a large stock point which provides wholesale and retail level supply support to various DOD activities in the western U.S. and limited support to various overseas commands. Major activities supported by NSC Oakland include NADEP Alameda, NASs Alameda, Moffett Field and Lemoore, Naval Shipyard Mare Island, and approximately 20 U.S. Navy ships homeported at naval facilities throughout the San Francisco Bay area. Additionally, NSC Oakland is a resupply point for Naval Supply Depots (NSDs) Guam, Yokosuka, and Subic Bay, and NSC Pearl Harbor. [Ref. 20:p. 2]

Several initiatives are underway at NSC Oakland which are designed to: consolidate physical distribution operations into fewer, more effectively used, core operations; change the type and levels of Defense Logistics Agency material stocked; reduce the quantity of bulk material carried; and, completely reorganize existing storage facilities in conjunction with a plan to lease over one-third of the existing covered storage and over one-half of the uncovered storage to the Port of Oakland. In addition, a formal quality improvement program is underway, a program which is supposed to complement EWP by identifying and removing the root causes of work process errors. [Ref. 21]

2. Activity Workload and Resource Indicators

Exhibit 3-7 displays NSC Oakland workload indicators, personnel resources, and funding resources for the fiscal years 1986, 1987, and 1988 (through 30 April 1988). Workload indicator measurement descriptions in Exhibit 3-7 are identical to the ones used to describe NSC Pensacola workload indicator measurements in Exhibit 3-1. The workload indicators represent monthly averages, while the personnel and funding resources are end of fiscal year totals. [Ref. 22]

FISCAL YEAR	1986	1987	1988
LINE ITEMS CARRIED	731,016	739,344	746,601
DEMANDS	157,167	141,482	130,140
ISSUES	117,202	102,300	96,433
RECEIPTS	28,293	28,973	31,030
NRFI INDUCTIONS	7,163	5,916	5,668
RFI RETURNS	6,347	6,178	4,942
PERSONNEL	1,902	1,745	1,648
FUNDING ($M)	71.9	71.2	66.2

Exhibit 3-7 Workload, Personnel, and Funding

3. Facilities

NSC Oakland is located near the port of Oakland on northeast San Francisco Bay and is comprised of 38 buildings with approximately 2,542,000 square feet of covered storage space and 948,562 square feet of outside storage space. [Ref. 20:pp. 31-32]

In addition to the facilities located at the main site, the NSC Oakland physical distribution function occurs at two additional geographically separate locations, NAS Alameda and Naval Shipyard Mare Island. The NSC Oakland annex located at NAS Alameda is responsible for providing material support for the NADEP Alameda repair and rework program, while the NSC Oakland annex located at Mare Island supports depot repair and overhaul at the Naval Shipyard.

4. Material Flow Improvements

Recommendations to improve the flow of material at NSC Oakland were a product of the Task A material flow analysis of the physical distribution function conducted at each of the separate NSC Oakland sites. The material flow analysis consisted of cost and technical analyses grouped into the following functional categories:

- Stow/Pick,
- Packing/Shipping,
- Other Recommendations.

Examples of material flow analysis recommendations which project significant savings and short term payback are shown

in Exhibits 3-7 and 3-8. A summary of material flow analysis recommendations made at NSC Oakland is provided in Appendix F. [Ref. 23:pp. 6-9]

E. SUMMARY

This chapter described each of the activities selected as a research site with a view toward providing an understanding of the uniquely different business environments under which Engineering the Workplace (EWP) was implemented. Plotted performance information was presented for NSC Pensacola to show how productivity measurement output resulting from Task B engineered performance standards could be used to monitor the productivity of work groups. Workload statistics were shown which provided an indication of increased tasking and decreasing funding and personnel resources at each activity. Material flow analysis recommendations were presented to show the quick payback and significant resource savings associated with the EWP process. An evaluation of the elements affecting the selected productivity indices at NSC Pensacola, and a discussion of EWP in relation to the Chapter I research questions is contained in the next chapter.

III.3 OTHER

RECOMMENDATION

III.3.1 Increase Material Handling Equipment (MHE) utilization to 40%.

SUMMARY OF SAVINGS

Cost = $0	Cost Avoidance = $638,000
Savings = $297,600/yr.	Payback Period = Immediate

AS-IS CONDITION

Material Handling Equipment (MHE) at the Naval Supply Center Oakland (NSCO) had a 23% utilization rate in fiscal year 1986 and a 21% utilization rate in fiscal year 1987. SPCC's goal for MHE utilization is 40%, which is conservative but allows for responding to peak workloads and provides an allowance for unique MHE which is not frequently used. Section II.7 of the Material Flow Analysis As-Is report shows total maintenance costs in Fiscal Year 1987 of $645,553. Therefore, the average maintenance cost for MHE in 1987 was $1600/unit, based on 1987 levels of maintenance support and equipment on hand.

DISCUSSION

Maintaining the same level of work, while significantly reducing the number of MHE requires some fundamental changes in the way MHE is used and allocated. Some of the factors contributing to the low utilization rate are the number of forktrucks versus total warehouse manpower, number of MHE in the Public Works Center (PWC) shop on any given day and methods used for intra-center movement of material.

ATI recommends that the number of pieces of MHE at NSCO be reduced so as to achieve an average utilization of 800 hours per year (the SPCC goal of 40%). Based on the hours MHE was utilized in 1987, there should be 215 pieces of MHE vice 409 pieces, which represents a 47% decrease in the number of MHE. Therefore, the MHE fleet should be reduced by 194 units.

ATI recognizes that major rewarehousing may delay implementation of this recommendation, due to the increased requirement for MHE during the rewarehousing efforts in earlier EWP recommendations, the NSCO core consolidation and the Port of Oakland Initiative.

Exhibit 3-7 Material Flow Analysis Recommendation

III.3 OTHER

RECOMMENDATION

III.3.13 Partially support Military Construction (MILCON) Project P-057 which calls for lighting conversion in various buildings.

SUMMARY OF SAVINGS

Costs	= $0	Cost Avoidance	= $902,000
Savings	= $0	Payback Period	= N/A

AS-IS CONDITION

The existing incandescent lamps burn out 2-3 times a year and typically 10-40% of the fixtures are out. On a typical day with all lamps that are operational turned on, the warehouse areas are still inefficiently and poorly lit. Existing illuminance was recorded at 5 foot-candles or less. Average lighting on-time is estimated to be 2687 hours per year. There are 17 buildings covered by this MILCON.

DISCUSSION

ATI supports only the portion of the lighting conversion project that applies to buildings within the core complex proposed by the Naval Supply Center Oakland (NSCO) master plan. Buildings outside this core complex will become essentially inactive once master plan objectives have been reached. The lighting requirements for inactive warehouses as stated by OSHA, is 5 foot-candles, which is what is presently found in these warehouses. Warehouses inside the core complex need an upgraded lighting system in order to comply with OSHA standards and to reduce maintenance and operating costs. Buildings outside the proposed core complex comprise 7 of 17 or 41% of the buildings covered by this MILCON, and therefore ATI does not support 41% of the MILCON request.

COSTS/SAVINGS/PAYBACK

Costs. $2.2 million - (.41)($2.2 million) = $1,298,000. This cost of $1,298,000 is included in the MILCON program. It is not a cost to the Engineering the Work Place (EWP) Program.

Cost Avoidance. $2.2 million - $1,298,000 = $902,000

Savings. $0

Payback Period. Not Applicable

Exhibit 3-8 Material Flow Analysis Recommendation

IV. DATA ANALYSIS

A. INTRODUCTION

The purpose of this chapter is to provide a qualitative and quantitative evaluation of the data which was presented in the previous chapter. First, qualitative evaluations of the following information will be offered:

- Activity workload and resource indicators,
- Productivity and performance data for the NSC Pensacola Receipt Processing Section, and Packing and Crating Section Two,
- Productivity and workload data for NSC Pensacola Packing Section Five,
- Data pertaining to the exportability of EWP,
- Information pertaining to EWP benefits.

Then, a regression analysis of NSC Pensacola performance and productivity and performance data will be presented. The focus of the regression analysis is to determine if their is a trend in this productivity and performance data since the implementation of EWP engineered performance standards.

B. QUALITATIVE ANALYSIS

1. Activity Workload and Resource Indicators

In Chapter III, information was presented for NSCs Pensacola, Jacksonville, and Oakland describing the workload and the personnel and funding resources.

a. NSC Pensacola Workload and Resources

The following evaluation of NSC Pensacola workload, personnel, and funding refers to Exhibit 3-1.

The average monthly range of line items carried has increased by 16,023 since 1986, representing a 17.84% increase. The increase in line item range suggests an increase in the capacity of supply support.

Average monthly demand has increased by 5,329 since 1986 (after a small decrease in 1987), representing an 18.42% increase since 1986. The increase in demands indicates increasing volume of customer business.

The average monthly issues have increased by 1,409 since 1986, representing a 5.48% increase since 1986. The increase in issues indicates a greater physical distribution workload, in response to an increasing volume of customer business.

Average monthly receipts have increased by 370 since 1986 (after a small decrease in 1987), representing a 3.24% increase. It is difficult to evaluate this negligible decrease, since receipts are counted documents representing one or more line items and do not directly affect workload.

NRFI inductions and RFI returns have decreased by 776 (15.08%) and 955 (18.97%), respectively. The decreases in inductions and returns could indicate decreased customer demand for aviation depot level repairables due to lower operating tempo, an increasing reliability of newer

generation depot level repairable components, a shifting of depot level maintenance to other locations, or a reduction in the number of aircraft supported.

The 28 (6.74%) fewer civilian personnel employed at NSC Pensacola in April 1988 as compared to 1986 reflects the loss of 39 people (18.14%) in the Physical Distribution Department and the gain of 11 (18.18%) in the functions associated with the staff organization, necessitated when Pensacola became a supply center.

The growth in funding from 1986 to 1987 resulted from the commissioning of Pensacola as a supply center, the resulting increase in NSC Pensacola's customer population, and the transfer of major claimant responsibility from CNET to NAVSUP. The decrease of $.6 million (3.58%) in funding from 1987 to 1988 reflects NSC Pensacola's share of NAVSUP budget reductions.

b. NSC Jacksonville Workload and Resources

The following evaluation of NSC Jacksonville workload, personnel, and funding refers to Exhibit 3-4.

The average monthly number of line items carried has increased by 22,531 since 1986, representing a 10.91% increase. The increase in line item range suggests an increase in the capacity of supply support.

Average monthly demands, issues, and receipts have decreased since 1986 by 10,670 (12.06%), 1,831 (3.36%), and 3,795 (16.66%), respectively. These decreases indicate

a lower volume of customer business and reflect a reduced operational tempo of NSC Jacksonvilles's major fleet customers. [Ref. 24]

NRFI Inductions and RFI returns have decreased by 1,008 (20.75%) and 749 (16.55%), respectively. This reduced volume of repairable components cycled through the NADEP Jacksonville depot level repair process could indicate lower fleet customer operational tempo, an increasing reliability of newer generation depot level repairable components, a shifting of depot level maintenance to other locations, or a reduction in the number of aircraft supported.

One hundred sixty one fewer personnel, 20.96% of the 1986 workforce, are on board NSC Jacksonville in 1988. The reduced number of employees reflects a management goal to bring personnel strength in line with actual workload under the "stovepipe" reorganization, and to increase employee productivity.

The decrease of $1.236 million (5.7%) in funding from 1986 to 1988 reflects NSC Jacksonville's share of NAVSUP budget reductions.

c. NSC Oakland Workload and Resources

The following evaluation of NSC Oakland workload, personnel, and funding refers to Exhibit 3-7.

The average monthly range of line items carried has increased by 15,585 since 1986, representing a 2.13%

increase. The increase in line item range suggests an increase in the capacity of supply support.

Since 1986, average monthly demands and issues have decreased by 27,027 (17.2%) and 20,769 (17.72%), respectively. These decreases indicate a lower volume of customer business which could reflect a change in the size or composition of the customer population, and/or a reduction in the operational tempo of NSC Oakland's major fleet customers.

Average monthly receipts have increased by 2,737 (9.67%) since 1986. The increase is consistent with the growth of line items carried, and reflects additions to the range of items carried by NSC Oakland under the DLA Streamlining Project (DLASP).[12]

NRFI inductions and RFI returns have decreased by 1,495 (20.87%) and 1,405 (22.14%), respectively. The decreases in inductions and returns could indicate decreased customer demand for depot level repairables, an increasing reliability of newer generation depot level repairable components, a shifting of depot level maintenance to other locations, or a reduction in the number or operational tempo of supported customers.

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[12] DLASP is a Defense Logistics Agency (DLA) initiative to replace certain low demand high cube defense stocks at DLA stock points with selected high demand smaller size components.

Two hundred fifty four fewer personnel, 13.35% of the 1986 workforce, are on board NSC Oakland in 1988. The reduced number of employees reflects a management goal to increase employee productivity and bring the workforce in line with actual workload.

Funding decreased $5.7 million (7.93%) from 1986 to 1988. The funding decrease reflects NSC Oakland's share of NAVSUP budget reductions.

2. Productivity Measurement Data[13]

a. NSC Pensacola Receipt Processing Section

The performance standard for the Receipt Processing Section was not changed between December 1987 and March 1988, although the daily workload varied. On-line receiving[14] operations commenced soon after the material flow analysis began, a factor which contributed to changing workload. An analysis of the productivity values in Appendix C on page 108, which are plotted in Figure 3-1, indicates the following features.

Productivity rose sharply during the December 1987 Christmas holiday period because 33% to 75% (between

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[13]Qualitative information on NSC Pensacola productivity and workload data was obtained from CDR G.A. Van Houweling, SC, USN, NSC Pensacola EWP Project Officer.

[14]On-line receiving refers to the immediate storage of material as soon as it arrives at a stock point. Before on-line receiving, material arriving at NSC Pensacola had to be staged for up to two days in a temporary location, requiring extra material material handling and manual tracking.

four and nine workers) of the section were on leave.[15] The productivity measured between 1 and 18 December 1987 averaged 67.4% whereas the productivity measured between 21 and 31 December averaged 81.8%, indicating that scheduled workload was distributed among fewer employees which resulted in greater production per employee. The drop in productivity during the last two workdays in December (from 83% on December 29 to 69% and 59% on December 30 and 31, respectively), is an indication that workload was insufficient to enable workers to earn enough standard hours to produce higher productivity.

The average productivity per month remained relatively stable from December 1987 through March 1988 (73.2% and 73.9%, respectively). This minimal change reflects an unchanging engineered performance standard and suggests that the allocation of workload among employees might have been increased.

The lowest daily productivity reported each month in the period was: 47% in December; 42% in January; 53% in February; and 52% in March. The mean of the lowest daily productivity values is 48.5%. The highest daily productivity reported each month for the same period was: 100% in December; 81% in January; 92% in February; and 95% in March. The mean of the highest daily productivity values

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[15]Data on employee leave is taken from the Level 1 Performance and Production Reports and is substantiated by activity leave records.

is 92.0%. The 43.5 percentage point difference between the mean reported low productivity and the mean reported high productivity indicates the possibility of a fluctuating daily receipt processing workload due to work scheduling.

b. NSC Pensacola Packing and Crating Section Two

The engineered performance standard for Packing and Crating Section Two was not changed between December 1987 and March 1988. A change in workflow from piece work to batch processing was initiated by the level 1 supervisor, a factor which resulted in a more level workload because containers were being batch produced and assembled using precut materials according to a quarterly estimate of containers required. As a result of the material flow analysis, the section began using labor saving devices (powered automatic nailing equipment) and efficient work processing stations. An analysis of the productivity values in Appendix D, which are plotted in Figure 3-2, indicates the following features.

Productivity rose sharply during the the December 1987 Christmas holiday leave period because 33% to 67% (between four and eight workers) of the section were on leave. Between 1 and 18 December the mean productivity was 65.2%, whereas the productivity measured between 21 and 31 December averaged 80.5%. The scheduled workload during the 21 to 31 December Christmas leave period was distributed

among fewer employees which resulted in greater productivity per employee.

The mean productivity per month increased from 71.2% in December to 83.1% in March.

The lowest daily productivity reported each month during the period was: 56% in December; 50% in January; 38% in February; and 66% in March. The mean of these daily productivity values is 52.5%. The highest daily productivity reported each month during the period was: 107% in December; 106% in January; 90% in February; and 99.9% in March. The mean of these daily productivity values is 92.0%. Larger variations in daily reported productivity are seen from December to mid-February, reflecting the piece work process used during that timeframe. From mid-February to March, more consistency is seen in reported productivity. This consistency is attributed to the implementation of batch work processing.[16]

3. <u>Productivity and Workload Data</u>

a. NSC Pensacola Packing Section Five

Packing Section Five is responsible for picking items to be issued to supply center customers from the bin and carousel areas of NSC Pensacola Building 781. Productivity and workload data for a 19 day period in May

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[16]It is the expert assessment of the EWP Project Officer and the Level 1 Supervisor that the reduced variation in reported productivity from mid-February to March can be attributed to a more stable workload brought about by the implementation of batch processing.

1988 was obtained and is plotted on Figure 4-1. Daily productivity (measured in percent), and scheduled workload (measured as hundreds of line items to be picked from bins and carousels for issue), is depicted. An evaluation of productivity versus picks for the period indicates the following features.

There is a correlation between productivity and the number of picks scheduled. For all but one observation, higher daily scheduled picks is accompanied by higher daily reported productivity for the period (and vice versa for lower daily scheduled picks and lower daily reported productivity).

The one instance of high daily scheduled picks and low daily reported productivity occurred on a Friday immediately before a scheduled Naval Reserve training weekend, and reflects a decision to set aside workload for the weekend reservists to accomplish. [Ref. 25]

4. EWP Exportability

EWP might be an appropriate methodology to apply to other stock point functions. As indicated in Chapter II, the work measurement procedure which EWP uses to create engineered performance standards, the Maynard Operation Sequence Technique (MOST), can be applied to various work situations involving the movement of material. A related sequence technique, called Clerical MOST, has been developed to measure the movements which occur most frequently within

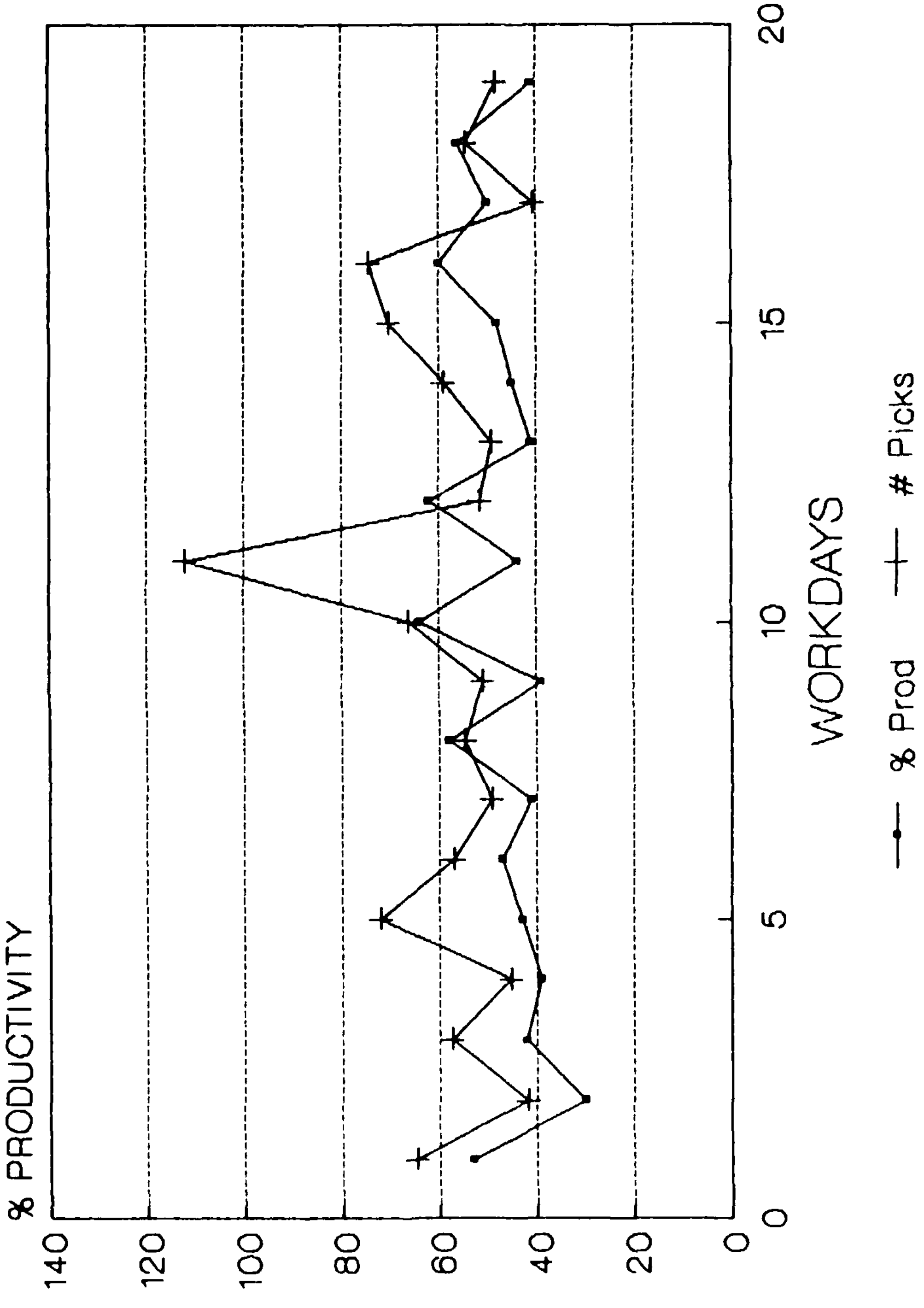

Figure 4-1 Packing Section Five Productivity vs. Workload

an office environment. Clerical MOST consists of fully indexed sequence models for General and Controlled Move, and Tool and Equipment Use, which are designed specifically to build a performance standard around various clerical functions that produce outputs which are difficult to quantify (like typing, filing, filling out reports, etc.). An application of Clerical MOST under EWP has been done in the NSC Pensacola Personal Property Section which has created a performance standard that considers the actions required of a personal property counselor to counsel a person regarding household goods. [Ref. 25]

NAVSUP has modified the EWP contract recently to include conducting material flow analyses at the following other activities:

- NSC Norfolk,
- Ships Parts Control Center (SPCC),
- Commander, Naval Logistics Command, U.S. Pacific Fleet (COMNAVLOGPAC).

At NSC Norfolk, EWP is being applied in the Physical Distribution Department. At COMNAVLOGPAC, EWP is being applied in the physical distribution departments at several Naval supply depots overseas. At SPCC, EWP is being applied in the Weapon System Provisioning Section, a section whose primary outputs are lists and documentation. [Ref. 26]

5. EWP Benefits

The objective of EWP is to improve the efficiency and effectiveness of the physical distribution operations at

the Naval supply centers. To achieve this objective, and to improve the quality, quantity, and timeliness of material flows, the material flow analysis provides an objective evaluation of the movement of material and associated documentation within a stock point. To be implemented, EWP requires the involvement of the workers and their supervisors. Throughout the process, EWP allows:

- each worker to understand how his job can be done efficiently, and how his job relates to the outputs and goals of the activity,
- each level 1 supervisor to understand the relationships of the work processes within his section, and how he can orchestrate his workforce to greater efficiency,
- each higher level manager to understand the relationships between functions, and how the workplace, workforce, and workload can be arranged, assigned, and scheduled for greater efficiency and productivity.

As Chapter II indicates, EWP emphasizes a comprehensive training program, which is designed to teach employees how to work efficiently, and where to look for improvements in work procedures.

This chapter presented an example of a level 1 supervisor in Packing and Crating Section Two initiating a change in workflow, from piece work to batch processing, which resulted in a more level workload. In the same work section, powered automatic nailing equipment and efficient work processing stations were benefits introduced from the material flow analysis.

The high degree of involvement of all levels of the organization in implementing EWP recommendations was evident

during the visits to NSCs Pensacola, Jacksonville, and Oakland. As indicated in Chapter III and in this chapter, work process improvements have not been limited to the recommendations made by the contractor resulting from the material flow analysis. Significant work process improvements have been obtained from level 1 supervisors and from the workforce.

Since analyzing material and establishing performance standards is a continuing process, which requires direct employee involvement and exposes employees to efficient work methods, EWP is a logical vehicle for positively transforming work attitudes and values.

C. QUANTITATIVE ANALYSIS

Regression analysis and the related group means difference test were used to determine the statistical significance of the December 1987 through March 1988 performance and productivity data for the NSC Pensacola Receipt Processing and Packing and Crating sections.

1. Regression Analysis

The purpose of the regression analysis is to develop a statistical model to:

- determine the linear functions that best fit the performance and productivity data for each section,
- measure the strength of the association between performance and productivity in each section,
- predict future values of section performance and productivity,

- determine whether there is a statistically significant trend present in the data.

2. Method of Regression Analysis

Measurements of section performance and productivity were taken from the Level 1 Performance and Production Reports and used as source data for a linear regression model using the least squares method resident in a microcomputer application of the Lotus 1-2-3 program. The data in Appendices C and D was used to graphically plot performance and productivity. Figures 4-2 and 4-3 show the plotted data. Performance and productivity values are plotted as percentages along the y-axis versus time (counting only the workdays between December 1987 and March 1988) on the x-axis.

3 Results of Regression Analysis

a. Simple Regression

Treating time (counting only workdays) as the independent variable (x_i), and performance and productivity as separate dependent variables (y_i), Exhibits 4-1 and 4-2 show the statistical output from the linear regression.

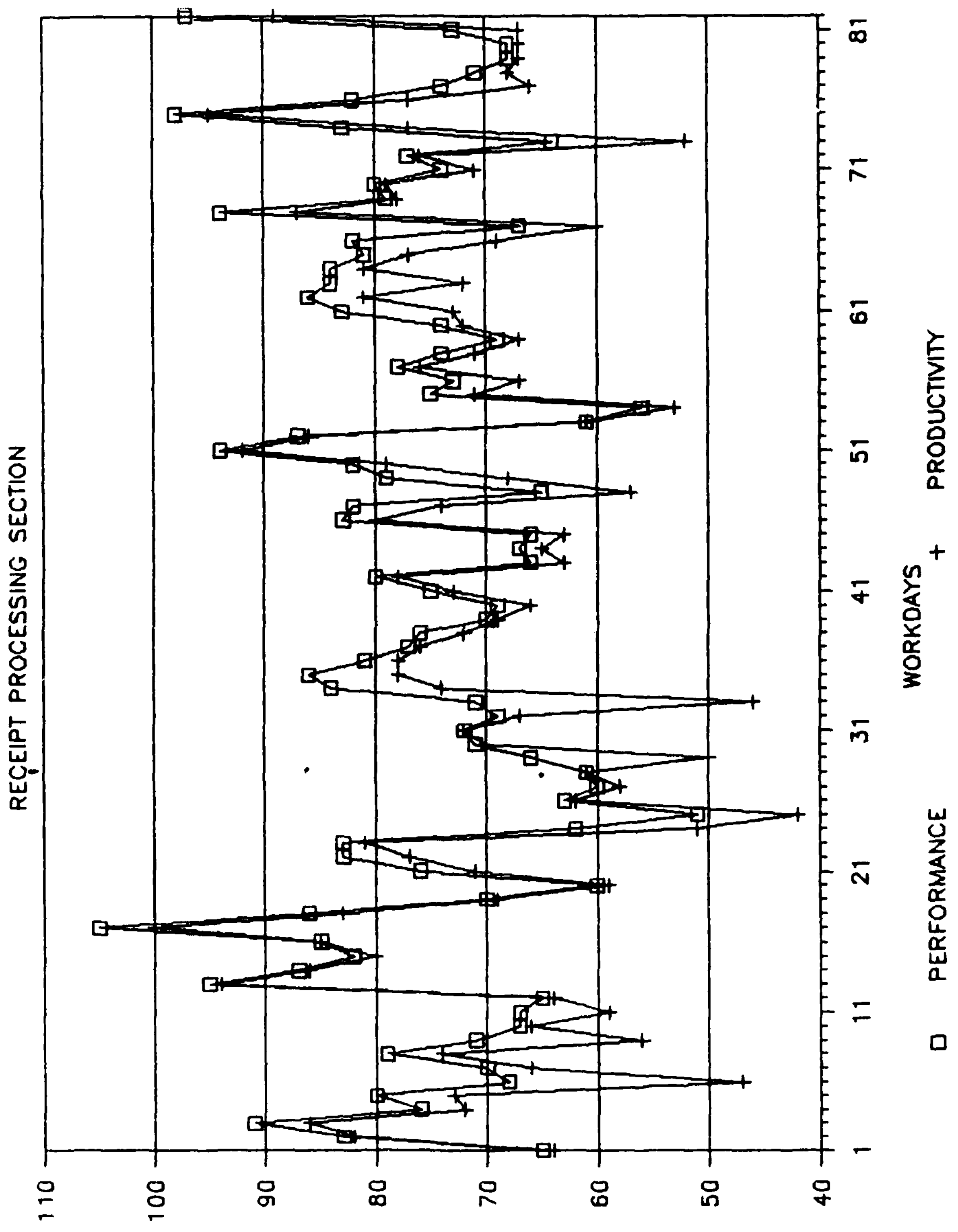

Figure 4-2 Receipt Processing Performance vs. Productivity

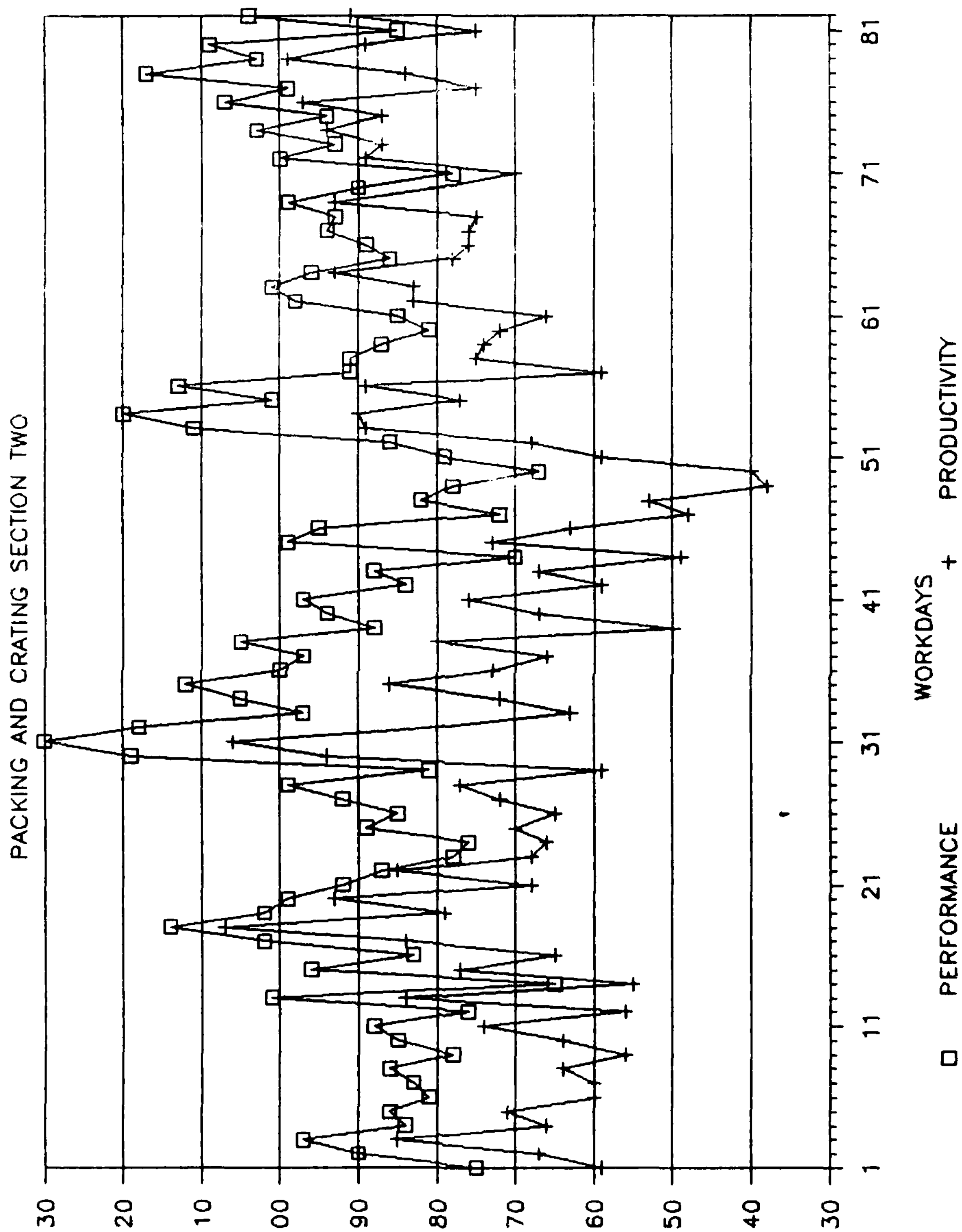

Figure 4-3 Packing and Crating Performance vs. Productivity

RECEIPT PROCESSING

REGRESSION STATISTIC	PERFORMANCE	PRODUCTIVITY
Constant (b_0)	73.94037	69.15537
x Coefficient (b_1)	.04552	.04709
Standard Error of y Estimate (s_{yx})	10.24965	11.39414
No. of Observations (n)	82	82
Degrees of Freedom (n-2)	80	80
Standard Error of x Coefficient (s_{b1})	.04782	.05316

Exhibit 4-1. Receipt Processing Regression

PACKING AND CRATING

REGRESSION STATISTIC	PERFORMANCE	PRODUCTIVITY
Constant (b_0)	87.88437	66.08220
x Coefficient (b_1)	.12444	.18579
Standard Error of y Estimate (s_{yx})	12.54908	13.62425
No. of Observations (n)	82	82
Degrees of Freedom (n-2)	80	80
Standard Error of x Coefficient (s_{b1})	.05855	.06356

Exhibit 4-2. Packing and Crating Regression

In Exhibits 4-1 and 4-2, using the linear equation for predicting the values of performance and productivity

$$y = b_0 + b_1 x$$

where:

b_0 = the y intercept of the regression line,

b_1 = the slope of the predicted line,

x = the value of the independent variable,

s_{b1} = the variability of the random variable governing the slope, b_1,

y = the predicted value of the dependent variable,

s_{yx} = the variability of the dependent variable about the regression line.

From the results of the Receipt Processing regression. the straight-line equations which best fit the data are:

- Predicted Performance = $73.94037 + .04552x_i$,
- Predicted Productivity = $69.15537 + .04709x_i$.

From the results of the regression shown on this page for Packing and Crating, the straight-line equations which best fit the data are:

- Predicted Performance = $87.88437 + .12444x_i$,
- Predicted Productivity = $66.08220 + .18579x_i$.

All the above equations show positive slopes to their fitted regression lines, which indicates increasing performance and productivity over the time period of the sample data.

b. Hypothesis Test

To determine whether the trends in these relationships are statistically significant, the following hypothesis test was performed for each section:

$$H_0: \; b_1 = 0$$

$$H_1: \; b_1 = 0$$

Receipt Processing regression output indicated:

- that there is no statistically significant non-zero slope in the relationship between workdays and performance or productivity.

Packing and Crating regression output indicated:

- that there is a statistically significant non-zero slope in the relationship between workdays and performance or productivity.

Therefore, although all the fitted sample data regression lines are positive, it can be inferred that the only statistically significant indication of an increase in performance and productivity is in Packing and Crating Section Two.

c. Coefficient of Determination

The coefficient of determination is regression output which measures the proportion of variation in one independent variable (performance) that is explained by the variability in the other independent variable (productivity), and vice versa.

Referring to Figure 4-2, a .829965 coefficient of determination for Receipt Processing indicates that 82.9965% of the variation in performance is explained by productivity, and vice versa. Referring to Figure 4-3, a .647441 coefficient of determination for Packing and Crating indicates that 64.7441% of the variation in performance is explained by productivity, and vice versa. The smaller coefficient of determination in Packing and Crating indicates that 35.2559% of the variability in performance

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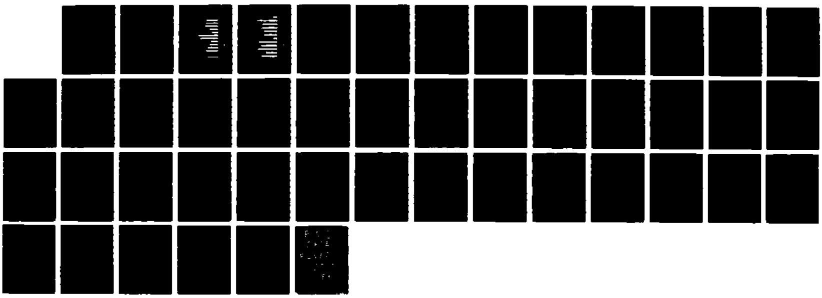

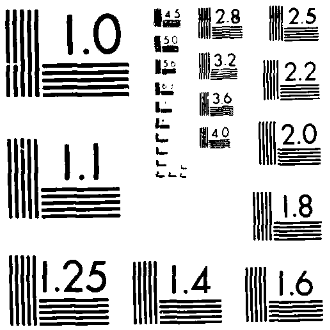

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can be explained by factors other than what has been accounted for by the linear regression model.

4. <u>Related Group Means Difference Test</u>

The purpose of the related group means difference test is to determine if a there is a statistically significant difference between employee productivity measured in one time period and employee productivity measured in another time period.

a. Method of Group Means Difference Test

Measurements of individual employee productivity were taken from the Level 1 Performance and Production Reports of each section and used to calculate the mean productivity of each individual for two time frames, December-January and February-March. The differences in the mean productivity between the two time periods were then used to test the null hypothesis which says that there is no statistically significant difference between the means of each time period. In Figures 4-4 and 4-5, mean productivity values of individual employees from Receipt Processing and Packing and Crating are plotted for two time frames. The x-axis indicates the mean percentage productivity value and the y-axis indicates the productivity values of each employee for each time period. Appendices G and H list the daily productivity measurements for each employee.

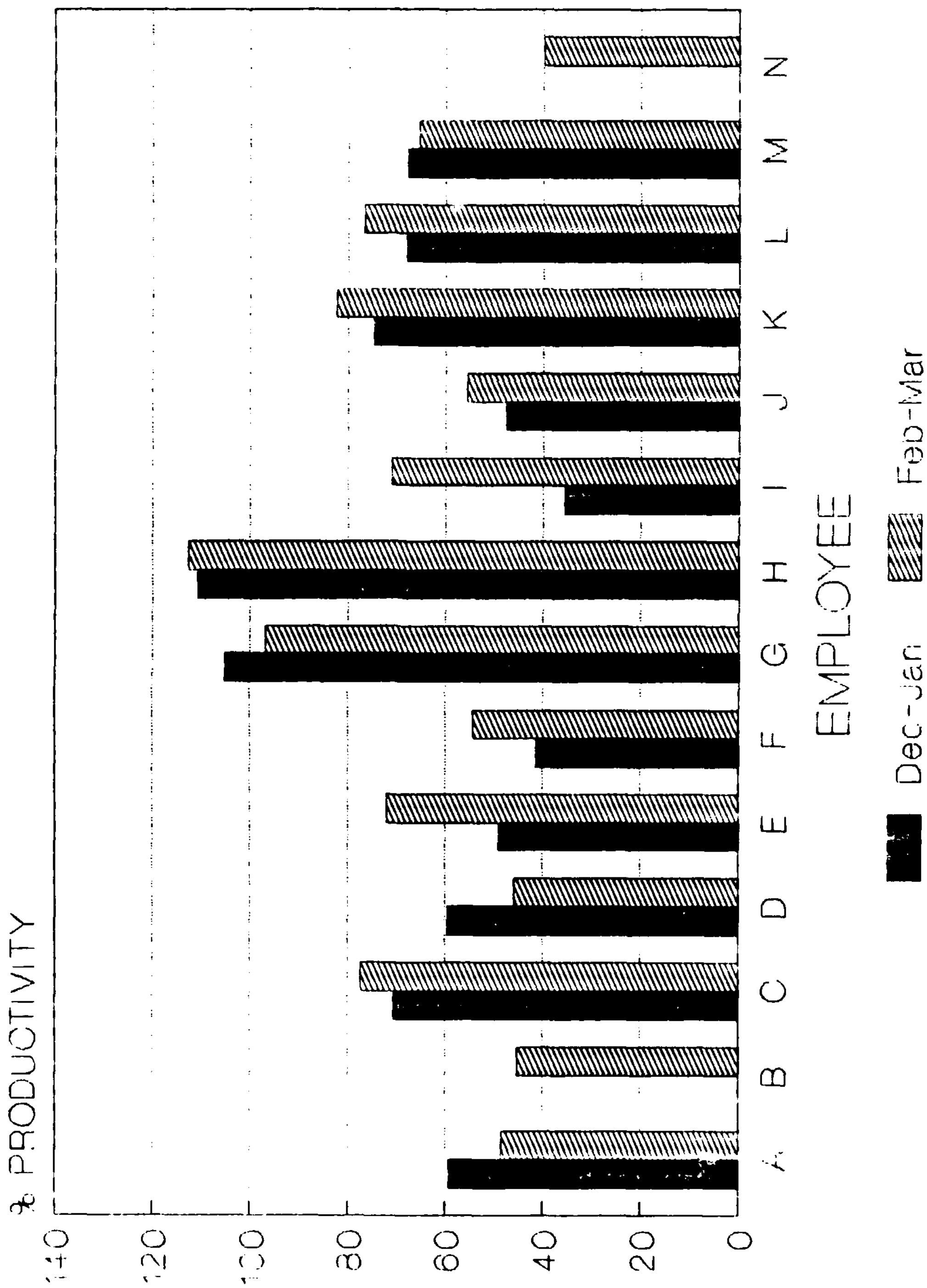

Figure 4-4   Receipt Processing Employee Productivity

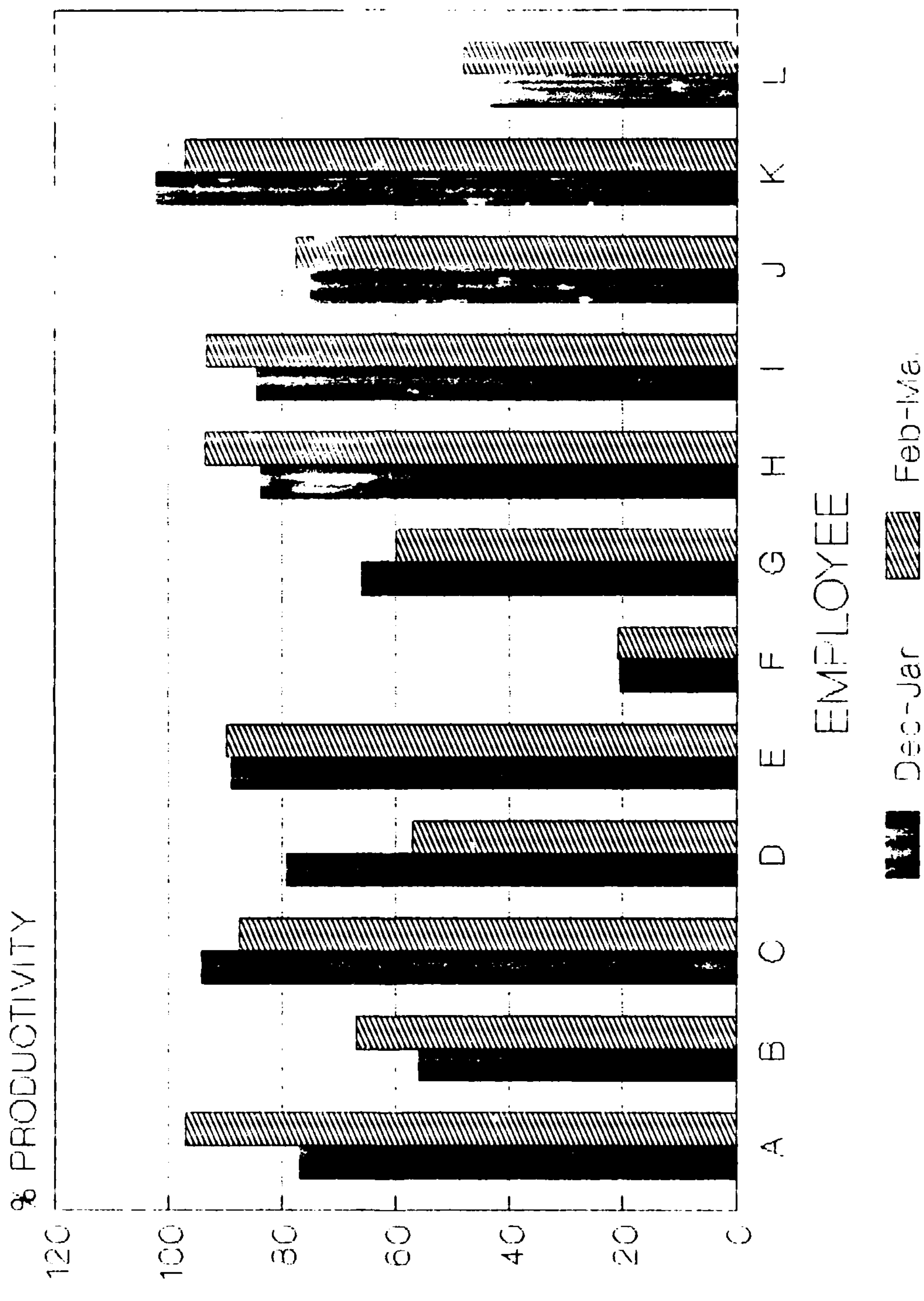

Figure 4-5 Packing and Crating Employee Productivity

b. Results of Related Group Means Difference Test

For both the Receipt Processing Section and Packing and Crating Section Two, the null hypothesis cannot be rejected. Therefore, there is no statistically significant difference between the mean productivity reported in the December-January time period and the mean productivity reported in the February-March time period.

D. SUMMARY

This chapter first presented a qualitative analysis of activity workload and resource indicators, productivity data from NSC Pensacola Receipt Processing and Packing and Crating sections, and productivity/workload data from NSC Pensacola Packing Section Five. The results of the qualitative analysis show a greater decline in personnel and funding resources than in workload, a moderate increase in section productivity over a four month time period, and a positive correlation between workload and productivity.

A quantitative analysis was then presented which showed that, although performance and productivity increased in a positive linear fashion, only Packing and Crating Section Two demonstrated a statistically significant increase. A test of individual employee productivity in each section over two time periods indicated that there was no statistically significant increase, although average individual productivity was shown to have increased.

The fact that the results of the quantitative analysis were moderately positive, yet insignificant statistically, reflects the maturity of EWP application in the two sample sections randomly chosen for the analysis. Each section had already implemented recommendations from the material flow analysis and was measuring performance using standards which had not changed over the time frame of analysis.

V. CONCLUSIONS AND RECOMMENDATIONS

A. PREFACE

This thesis attempted to answer the following primary research question: Is Engineering the Workplace (EWP) an appropriate methodology to apply to other functional areas of a stock point, and if so, into what other areas might EWP be exported?

To evaluate the exportability of EWP, factors presented in earlier chapters are summarized in the first conclusion of this chapter. Presented also are other conclusions, based on research information introduced in earlier chapters of this thesis, which indicate that EWP:

- may have benefits, not readily measurable by objective means, which could have long term effects on the employees of an organization,
- is a methodology which can lead to reduced operation and personnel costs over a short period of time,
- may lead to improved productivity and performance.

Finally, recommendations will be offered which intend to address areas where EWP could be improved.

B. CONCLUSIONS

1. Conclusion 1

EWP may be an appropriate methodology to apply to other than stock point physical distribution functions.

As indicated in Chapter II, the work measurement procedure which EWP uses to create engineered performance standards, the Maynard Operation Sequence Technique (MOST), is being applied to various work situations involving the movement of material. A related sequence technique, called Clerical MOST has been developed to measure the movements which occur most frequently within an office environment. A recent EWP program update from NAVSUP indicates that several actions are underway to apply EWP methodology to functions other than physical distribution. [Ref. 26] As indicated in Chapter IV, the NSC Pensacola Personal Property Section and the SPCC Weapon System Provisioning Section are two areas where EWP is being applied in functions other than physical distribution. The Clerical MOST fully indexed sequence models for General and Controlled Move, and Tool and Equipment Use, are being used at NSC Pensacola and SPCC to build performance standards around various "white collar" functions that produce outputs which are difficult to quantify (like processing parts lists, filling out reports, counseling people, etc.). Although the above two applications support the exportability of EWP, insufficient performance data has been produced on which to measure the success of EWP application in non-physical distribution areas.

2. <u>Conclusion 2</u>

Significant EWP benefits may lie in areas other than performance measurement and statistical process control.

As indicated in Chapter III, significant work process improvements have generated from level 1 supervisors and from the workforce. Several EWP organizational benefits have been observed during the visits to NSCs Pensacola, Jacksonville, and Oakland. These organizational benefits include:

- creating an environment which encourages employees to continually seek opportunities for improving the quality of the their work,
- exposing employees to efficient work methods,
- involving workers and their supervisors together in implementing the EWP process,
- EWP being a logical vehicle for positively transforming work attitudes and values,
- involving higher level managers in the EWP implementation process and encouraging them to consider the relationships between functions, and how to make the workplace, workforce, and workload more efficient.

3. <u>Conclusion 3</u>

EWP is a methodology which can lead to reduced operation and personnel costs over a short period of time.

As indicated in Chapter III and Appendices B, E, and F, material flow analysis recommendations for NSCs Pensacola, Jacksonville, and Oakland have projected the following savings in conjunction with EWP implementation:

- reducing labor by over 100 billets,
- reducing operations costs by approximately $5.2 million in less than two years by changing work methods,
- avoiding over $46 million in costs in less than two years by eliminating duplication and inefficiency.

Actual savings at NSC Pensacola since EWP implementation are estimated at over $1.5 million.

4. Conclusion 4

There is limited evidence which indicates that EWP may improve productivity and performance.

Chapter IV presented a quantitative analysis of performance and productivity data from the NSC Pensacola Receipt Processing and Packing and Crating sections which showed that, although performance and productivity increased in a positive linear fashion, only Packing and Crating Section Two demonstrated a statistically significant increase. A test of individual employee productivity in the above sections over two time periods indicated that there was no statistically significant increase, although average individual productivity was shown to have increased.

C. RECOMMENDATIONS

Although EWP is a methodology designed to improve the productivity of workers and the efficiency of the workplace, it is not a process which can be applied to every activity without modification. Nor is EWP a process which can flourish without a strong management commitment to make it work or without compensation and incentive systems that

encourage and reward efficiency and quality. Even though EWP creates and maintains a performance measurement system, it is difficult to relate reported performance and productivity to actual work outputs. It is even more difficult to relate performance and productivity to the productive units on which NAVSUP bases an activity's operational funding. It is also difficult to relate cost savings directly to specific quality improvements or work process changes.

1. Recommendation 1

To encourage efficiency and quality in the workplace and recognize the high productivity and improved performance of individual workers and work groups, NAVSUP should provide guidance to activities using EWP, on how objective performance data in the EWPSS and EWPPES reports should be used in the civilian performance appraisal process to base recognition and incentive award levels.

2. Recommendation 2

To relate performance and productivity to work output, the Naval supply centers using EWP should include scheduled workload and completed work information in EWPSS and EWPPES reports. The inclusion of workload data in EWP reports would provide management the information needed to give meaning to performance and productivity measurements.

3. <u>Recommendation 3</u>

NAVSUP should develop an index or mathematical model to relate EWP performance and productivity measurements and workload to the productive units on which an activity's operational funding is based.

4. <u>Recommendation 4</u>

Each activity using EWP should:

- relate cost savings to specific EWP quality improvements or work process changes by recording quality improvement and work process change information in EWPSS reports when the improvements occur,

- closely monitor the implementation of material flow analysis recommendations to identify cost savings when it occurs.

5. <u>Recommendation 5</u>

Although projected EWP costs and cost savings are identified in material flow analysis recommendations, NSCs Pensacola and Jacksonville are accounting for actual cost savings associated with implementing EWP using different definitions for what constitutes an EWP related benefit.[17] NSC Pensacola defines an EWP related benefit as a benefit which is directly linked to a material flow analysis recommendation. NSC Jacksonville considers both direct benefits and benefits arising from efficiencies which relate indirectly to material flow analysis recommendations (such as improvements in work processes initiated by level 1

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[17]At NSC Oakland, a review was not made in this area, because EWP was too early in its development to provide conclusive information.

supervisors). The NAVSUP EWP Project Office should promulgate guidelines, regarding the definition and recording of actual EWP cost savings, to activities using EWP.

D. RECOMMENDATIONS FOR FURTHER RESEARCH

Two areas related to EWP are recommended for further research.

1. There is no direct relationship between EWP performance and productivity measurements and workload to the productive units on which NAVSUP bases an activity's operational funding. Research should be performed in an effort to develop an index or mathematical model which can relate the above measures.

2. The quantitative analysis presented in this thesis evaluated performance and productivity measurements recorded over a limited (four month) time period. To obtain quantitative information indicating whether or not there is a statistically significant trend, research should be done using EWP performance and productivity measures recorded over a longer time period.

APPENDIX A

MATERIAL HANDLING PRINCIPLES[18]

1. Orientation Principle: Study the system relationships thoroughly prior to preliminary planning in order to identify existing methods and problems, physical and economic constraints, and to establish future requirements and goals.

2. Planning Principle: Establish a plan to include basic requirements, desirable options, and the consideration of contingencies for all material handling and storage activities.

3. Systems Principle: Integrate those handling and storage activities which are economically viable into a coordinated system of operation including receiving, inspection, storage, production, assembly, packaging, warehousing, shipping, and transportation.

4. Unit Load Principle: Handle product in as large a unit load as practical.

5. Space Utilization Principle: Make effective utilization of all cubic space.

6. Standardization Principle: Standardize handling methods and equipment wherever possible.

7. Ergonomic Principle: Recognize human capabilities and limitations by designing material handling equipment and procedures for effective interaction with the people using the system.

8. Energy Principle: Include energy consumption of the material handling systems and material handling procedures when making comparisons or preparing economic justifications.

9. Ecology Principle: Minimize adverse effects on the environment when selecting material handling equipment and procedures.

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[18] R.A. Kulwiec, Materials Handling Handbook, 2nd ed. (New York: John Wiley & Sons, 1985), p. 12. [Ref. 11]

10. Mechanization Principle: Mechanize the handling process where feasible to increase efficiency and economy in the handling of materials.

11. Flexibility Principle: Use methods and equipment which can perform a variety of tasks under a variety of operating conditions.

12. Simplification Principle: Simplify handling by eliminating, reducing, or combining unnecessary movements and/or equipment.

13. Gravity Principle: Utilize gravity to move material wherever possible, while respecting limitations concerning safety, product damage, and loss.

14. Safety Principle: Provide safe material handling equipment and methods which follow existing safety codes and regulations in addition to accrued experience.

15. Computerization Principle: Consider computerization in material handling and storage systems, when circumstances warrant, for improved material and information control.

16. System Flow Principle: Integrate data flow with the physical material flow in handling and storage.

17. Layout Principle: Prepare an operational sequence and equipment layout for all viable system solutions, then select the alternative system which best integrates efficiency and effectiveness.

18. Cost Principle: Compare the economic justification of alternate solutions in equipment and methods on the basis of economic effectiveness as measured by expense per unit handled.

19. Maintenance Principle: Prepare a plan for preventive maintenance and scheduled repairs on all material handling equipment.

20. Obsolescence Principle: Prepare a long range and economically sound policy for replacement of obsolete equipment and methods with special consideration to after-tax life cycle costs.

APPENDIX B

NSC PENSACOLA MFA RECOMMENDATIONS-COST SUMMARY

I. RECEIVING

I.1	ABOLISH GENERAL FOREMEN
I.2	INSTALL ROLLER CONVEYER
I.3	COMMENCE ON LINE RECEIVING (ABE)

II. STOW/PICK

II.1	COLLECT WEIGHT AND CUBE DATA
II.2	SHOW FAST/SLOW ON STOW CARD
II.3	INTRODUCE SCHEDULING
II.4	CHANGE HIGH RISE PICKERS
II.5	RELOCATE FAST MOVING PALLETS TO K,L,M
II.6	BAR CODE LOCATIONS
II.7	CONSOLIDATE SLOW MOVING PALLETS TO K,L,M,A,B, HIGH
II.8	REMOVE OVERHEAD CONVEYER
II.9	MOVE BINS TO I & J
II.10	BIN CAROUSEL LADDERS
II.11	CONVERT TO 9' AISLES
II.12	CONVERT TO NARROW AISLES
II.13	REDUCE OFFICE/ADMIN BREAK AREAS
II.14	ABOLISH FOREMAN POSITION
II.15	ABOLISH FOREMAN POSITION
II.16	PLACE EXCESS LIFT TRUCKS OUT OF SERVICE
II.17	BAR CODE SHELF LIFE
II.18	COOL WAREHOUSE
II.19	FULLY USE RACKS IN A TO F & BINS I TO J
II.20	CHANGE 3 HIGH RACKS TO 4 HIGH RACKS
II.21	RELOCATE MTIS FROM D TO LOW BAY AREA
II.22	BLOCK STORAGE

III. PACK/SHIP

III.1	ABOLISH GENERAL FOREMAN POSITION
III.2	INSTALL HOIST OR PIGGYBACK ON PWC FLATBED
III.3	INSTALL NAVADS
III.4	MOVE PACKING AND SHIPPING TO G
III.5	NARF RECEIVING
III.6	REDUCE FLATBEDS RENTED FROM PWC

IV. OTHER

IV.1 USE INTERMITTENTS
IV.2 QA EMPLOYEE ADJUSTMENT
IV.3 EXPAND DBASE FILES
IV.4 ELIMINATE LOGS
IV.5 SERVMART EPOS
IV.6 BAR CODE AND RF INDUCTION RETURN
IV.7 USE POWER ASSISTED PEDESTRIAL TRUCKS
IV.8 ABOLISH CLERICAL FOREMAN

CATAGORIES	LABOR SAVINGS (WHITE)	LABOR SAVINGS (BLUE)	LABOR SAVINGS (DOLLARS)	UTILITIES MAINTENANCE OTHER ($$)	TOTAL SAVINGS (DOLLARS)	TOTAL COSTS (DOLLARS)	COST AVOIDANCE (SQ/FT)	COST AVOIDANCE OTHER ($$)	COST AVOIDANCE TOTAL ($$)
RECEIVING									
I.1	1.00		$37,781		$37,781				$0
I.2		0.90	$21,733		$21,733	$31,000			$0
I.3	2.80	2.63	$125,731	$3,500	$129,231				$0
	3.80	3.53	$185,245.00	$3,500.00	$188,745.00	$31,000.00	0.00	$0.00	$0.00
STOW/PICK									
II.1		0.03	$811		$811	$15,550	17,297		$69,188
II.2					$0	$25,000			$0
II.3	1.72		$38,221		$38,221	$22,222			$0
II.5		4.80	$115,910	$10,500	$126,410	$2,134			$0
II.6		0.34	$8,210		$8,210	$9,000			$0
II.7		1.56	$37,671	$37,900	$75,571	$1,498	60,000		$240,000
II.8					$0		5,200		$20,800
II.9		3.36	$81,282		$81,282	$32,604			$0
II.10					$0	$1,694			$0
II.11					$0	$8,000	25,195		$100,780
II.13					$0		1,000		$4,000
II.14		2.00	$75,562		$75,562				$0
II.15		1.00	$27,122		$27,122				$0
II.16				$56,000	$56,000				$0
II.17					$0	$17,500			$0
II.18		0.54	$12,986		$12,986	$75,000			$0
II.19					$0			$55,450	$55,450
II.20					$0	$21,300		$21,300	$21,300
II.21					$0	$2,000	1,800		$7,200
II.22					$0		37,750		$151,000
	1.72	13.63	$397,775.00	$104,400.00	$502,175.00	$225,502.00	123,047	$76,750.00	$568,938.00
PACK/SHIP									
III.1		1.00	$37,781		$37,781				$0
III.2		0.60	$14,489		$14,489	$13,000			$0
III.3		4.97	$120,015		$120,015	$22,222			$0
III.4				$26,484	$26,484	$63,000	20,000		$80,000
III.5				$51,300	$51,300				$0
III.6				$120,000	$120,000				$0
	0.00	6.57	$172,285.00	$197,784.00	$370,069.00	$98,222.00	20000.00	$0.00	$80,000.00
OTHER									
IV.1					$0				$0
IV.3					$0	$22,222			$0
IV.4		2.00	$48,296		$48,296				$0
IV.5	2.00	1.00	$68,592	$10,000	$78,592	$62,000			$0
IV.6		0.15	$3,622		$3,622				$0
IV.7				$61,620	$61,620				$0
IV.8	1.00		$24,122		$24,122				$0
	3.00	3.15	$144,632.00	$71,620.00	$216,252.00	$84,222.00	0.00	$0.00	$0.00
TOTALS	8.52	26.88	$899,937.00	$377,304.00	$1,277,241.00	$438,946.00	143,047	$76,750.00	$648,938.00

APPENDIX C

NSC PENSACOLA RECEIPT PROCESSING SECTION
PERFORMANCE/PRODUCTIVITY

2 December 1987--31 March 1988

Day	Dec 87	Jan 88	Feb 88	Mar 88
1			69/66	74/72
2	65/64		75/73	83/73
3	83/82		80/78	86/81
4		76/71	66/63	84/72
5		83/77	67/65	
6		83/81		
7	91/86	62/51		84/81
8	76/72	51/42	66/63	81/77
9	80/73		83/80	82/69
10	68/47		82/74	67/60
11	70/66	63/62	65/57	94/87
12		60/58	79/68	
13		61/61		
14	79/74	66/50		79/78
15	71/56	71/70		80/79
16	67/66		82/79	74/71
17	67/59		94/92	77/76
18	65/64		87/86	64/52
19		72/72	61/61	
20		69/67		
21	95/94	71/46		83/77
22	87/86	84/74	56/53	98/95
23	82/80		75/71	82/77
24	85/85		73/67	74/66
25		86/78	78/76	71/68
26		81/78	74/71	
27		77/76		
28	105/100	76/72		68/67
29	86/83	70/69	69/67	68/67
30	70/69			73/67
31	60/59			97/89

	Performance	Productivity
Mean	75.82926	71.10975
Variance	103.65370	127.90250
Std Dev	10.18104	11.30940

APPENDIX D

NSC PENSACOLA PACKING & CRATING SECTION TWO PERFORMANCE/PRODUCTIVITY

2 December 1987--31 March 1988

Day	Dec 87	Jan 88	Feb 88	Mar 88
1			94/67	81/72
2	75/59		97/76	85/66
3			84/59	98/83
4	90/67	92/68	88/67	101/83
5		87/85	70/49	
6		78/68		
7	97/85	76/66		96/93
8	84/66	89/70	99/73	86/78
9	86/71		95/63	89/76
10	81/60		72/48	94/76
11	83/60	85/65	82/53	93/75
12		92/72	78/38	
13		99/77		
14	86/64	81/59		99/93
15	78/56	119/94		90/80
16	85/64		67/40	78/70
17	88/74		79/59	100/89
18	76/56		86/68	93/86
19		130/106	111/89	
20		118/80		
21	101/84	97/63		103/94
22	65/55	105/72	120/90	94/87
23	96/77		101/77	107/97
24	83/65		113/89	99/75
25		112/86	91/59	117/84
26		100/73	91/75	
27		97/66		
28	102/84	105/80		103/99
29	114/107	88/50	87/74	109/89
30	102/79			85/75
31	99/93			104/91

	Performance	Productivity
Mean	93.04878	73.79268
Variance	162.31460	200.43260
Std Dev	12.74027	14.15742

APPENDIX E

NSC JACKSONVILLE MFA RECOMMENDATIONS-COST SUMMARY

1.1 Reduce receiving time for items purchased locally.

1.2 Eliminate double handling of medium sized material.

1.3 Consolidate Material Support Division Functions in South Area.

1.4 Eliminate double counting of material.

2.1 Optimize use of core North Area warehousing assets.

2.2 Send dead stock to disposal.

2.3 Increase storage capacity of existing warehouses through layout for increased storage with narrow aisle, high-stacking MHE.

2.4 Increase existing high rise rackables storage in B109 by extending racks 18 feet to south wall.

3.1 Load Mayport material directly to local drayage carrier trailers in South Area.

3.2 Load Seavans for Guantanamo Bay in South Area.

3.3 Eliminate obsolete vehicles and rental equipment from MHE fleet.

3.4 Establish standard practices for repetitive operations in the Packing and Blocking/Bracing Branch.

4.1 Increase use of intermittent personnel.

4.2 Use standard boxes in place of custom manufactured boxes thus eliminating the box making operation.

4.3 Do not implement layout for Building 108.

4.4 Deliver fleet (except carriers) Quicktrans material to B191, not the carrier pier.

4.6 Purchase a second flatbed trailer and eliminate the mule trains.

4.7 Eliminate excessive Material Handling Equipment (MHE) from the FSC Distribution Branch.

4.8 Reduce manpower in FSC SERVMART by leveling the workload.

4.9 Reduce use of local logs, reports, and files.

4.10 Miscellaneous methods, layout, and equipment improvements.

4.11 Do not support construction of Bulk Storage Warehouse (MILCON P-520).

4.12 Support alterations to flammable/hazardous storage facility (MILCON P-517).

4.13 Determine the best use of the addition to Building 191 (MILCON P-110).

4.14 Do not support the addition to the Building 192 Cold Storage facility (MILCON P-519).

RECOMMENDATION NUMBER	LABOR SAVINGS ($)	LABOR SAVINGS WG	LABOR SAVINGS GS	OTHER SAVINGS ($)	TOTAL SAVINGS ($)	TOTAL COSTS ($)	WHSE SAVINGS (SQ FT)	WHSE SAVINGS ($)	COST AVOID. ($)	PAYBACK PERIOD (MONTHS)
III 1 RECEIVING										
III.1.1	$165,670	1.35	6.00		$165,670	*				UNDETERMINED
III.1.2	$25,479	1.33			$25,479	$17,105				8.1
III.1.3	$19,968		1.00		$19,968					IMMEDIATE
III.1.4	$19,157	1.00			$19,157					IMMEDIATE
SUBTOTAL	$210,274	3.68	7.00		$210,274	$17,105				
III 2 PICK/STOW										
III.2.1	$146,190	7.63		$58,035	$204,225	$176,740	24,026	$79,286	$427,286	10.4
III.2.2						$92,801	142,458	$470,111	$470,111	
III.2.3	$18,881	0.99		$38,690	$57,571	$77,635	8,368	$27,614	$27,614	16.2
III.2.4	$5,167	0.27		$9,673	$14,840	$26,213	5,538	$18,277	$18,277	21.2
SUBTOTAL	$170,237	8.89		$106,398	$276,635	$373,389	$180,390	$595,289	$943,289	
III 3 PACK/SHIP										
III.3.1	$18,420	0.96		$19,346	$37,766					IMMEDIATE
III.3.2	$9,210	0.50		$9,673	$18,883		320	$1,056	$1,056	IMMEDIATE
III.3.3				$107,200	$107,200					IMMEDIATE
III.3.4	$19,157	1.00			$19,157	$7,650				4.8
SUBTOTAL	$46,787	2.47		$136,219	$183,006	$7,650	320	$1,056	$1,056	IMMEDIATE
III 4 OTHER										
III.4.1	$785,437	41.00		$253,014	$1,038,451					
III.4.2	$19,157	1.00		$32,479	$51,636					IMMEDIATE
III.4.3										IMMEDIATE
III.4.4	$9,210	0.48			$9,210				$24,000	IMMEDIATE
III.4.6	$27,630	1.44			$27,630	$20,000				IMMEDIATE
III.4.7				$4,128	$4,128				$12,600	8.7
III.4.8	$36,840	1.92			$36,840					IMMEDIATE
III.4.9										IMMEDIATE
III.4.10										IMMEDIATE
III.4.11										IMMEDIATE
III.4.12									$4,800,000	IMMEDIATE
III.4.13										
III.4.14									$760,000	
SUBTOTAL	$878,274	45.85		$289,621	$1,167,895	$20,000	0	$0	$5,596,600	
TOTAL	$1,305,572	60.88	7.00	$532,238	$1,837,810	$418,144	180,710	$596,345	$6,540,945	

APPENDIX F

NSC OAKLAND MFA RECOMMENDATIONS-COST SUMMARY

III.1 STOW PICK

1.1 Relocate fast moving material from bin buildings 312/313, and deactivate the Automated Material Handling System (AMHS).

1.2 Relocate binnable items out of Building 412.

1.3 Rewarehouse fast moving items out of 700/800 buildings.

1.4 Place all shelf-life items under NISTARS process control.

1.5 Consolidate material with multiple locations into single locations/areas.

1.6 Improve material flow within Building 513, Metals Center.

1.7 Complete implementation of bar code stow.

III.2 PACK/SHIP

2.1 Ship United Parcel Service (UPS) material directly from Building 422.

2.2 Replace cap and strap method of packing with shrink wrap system.

2.3 Use Naval Supply Center Oakland (NSCO) personnel to perform Bay Area Local Delivery (BALD).

2.4 Package and preserve Subsafe/Level 1 material at Mare Island.

2.5 Ship Parcel Post material from Door #7 in Building 433.

2.6 Relocate Code 604 United Parcel Service (UPS) shipping to the vicinity of the NISTARS elevator.

2.7 Use Local Delivery drivers to unload and load trucks at Code 600 storage locations.

III.3 OTHER

3.1 Increase Material Handling Equipment (MHE) utilization to 40%.

3.2 Perform Material Handling Equipment (MHE) minor repairs and road service calls with Naval Supply Center Oakland (NSCO) personnel.

3.3 Eliminate a dispatcher position from Building 331, Code 405.1.

3.4 Use commercial contractor for Material Handling Equipment (MHE) tire repairs.

3.5 Immediately reduce use of local logs, reports and files.

3.6 Increase use of intermittent personnel and flexible work hours.

3.7 Replace Red Line Manifest System with NAVADS tracking.

3.8 Maximize use of SERVMART.

3.9 Improve utilization of space in Building 170.

3.10 Recommendations on FY88 Planned Investment Program for Equipment Replacement (PIPER) requests.

3.11 Support construction of the compressed gas cylinder storage shed in MILCON Project P-108.

3.12 Partially support energy improvement for B311 and B312 in MILCON Project P-204.

3.13 Partially support MILCON Project P-057 which calls for lighting conversion in various buildings.

3.14 Support construction of high rise warehouse at Naval Air Station Alameda in MILCON Project P-121.

3.15 Partially support safety improvement to comply with OSHA egress requirements for six buildings in MILCON Project P-070.

3.16 Support facility improvements in MILCON Project P-205.

3.17 Do not support construction of a new Hazardous/Flammable (HAZ/FLAM) storage facility in MILCON Project P-112.

3.18 Do not support construction of transit facility, MILCON Project P-097.

3.19 Conditionally support installation of fire protection systems for Buildings 512 and 513 in MILCON Project P-063.

3.20 Support construction of general purpose warehouse in MILCON Project P-088.

3.21 Do not support the alteration/improvement to the General Office area at the N.W. corner of B322, MILCON Project P-077.

3.22 Do not support construction of an automated mechanized warehouse for the storage of steel cable, petroleum, oil and lubricants, MILCON Project P-048.

3.23 Do not support construction of an automated steel storage system in place of B521, MILCON Project P-047.

3.24 Support construction of general purpose warehouse in MILCON Project P-089.

NSC OAKLAND COST/SAVINGS SUMMARY

RECOM (#)	LABOR SAVINGS WG/GS	LABOR SAVINGS ($)	TOTAL SAVINGS ($)	TOTAL COSTS ($)	COST AVOID ($)	PAYBACK PERIOD (MOS)
1.1	5/0	170,350	487,240	217,838	0	5.4
1.2	.3/0	10,356	10,356	0	0	0
1.3	1.8/0	60,289	61,609	13,862	0	2.7
1.4	2.8/0	90,775	90,775	20,560	0	2.7
1.5	3.3/0	108,157	108,157	34,613	0	3.8
1.6	.7/0	22,539	22,539	10,444	0	5.6
1.7	.2/0	4,866	4,866	0	0	0
Sub	14.1/0	467,332	785,542	297,317	0	---
2.1	.3/0	5,538	14,951	0	0	0
2.2	.7/0	22,541	29,301	43,522	0	17.8
2.3	(10/0)	(343,368)	279,694	0	0	0
2.4	.5/0	16,401	16,401	0	7,208	0
2.5	.1/0	2,957	2,957	84	0	0.3
2.6	.2/0	5,228	5,228	5,400	0	12.4
2.7	.2/0	6,842	6,842	0	0	0
Sub	(8/0)	(283,861)	355,374	49,006	7,208	--
3.1	0	0	297,600	0	638,000	0
3.2	(3/0)	(112,224)	128,781	6,519	0	0.6
3.3	1/0	36,858	36,858	0	0	0
3.4	0	0	9,873	4,766	40,000	5.8
3.5	0.4/1.8	68,422	68,422	0	0	0
3.6	0*	820,272	820,272	0	0	0
3.7	1.3/0	40,248	41,143	4,233	0	1.2
3.8	0	0	115,812	0	0	0
3.9	1.5/0	48,298	48,298	38,919	0	9.7
Sub	1.2/1.8	901,874	1,567,059	54,437	678,000	--

*Labor savings accrue primarily from reduction in overtime use; therefore, no personnel savings are indicated.

RECOM (#)	LABOR SAVINGS WG/GS	LABOR SAVINGS ($)	TOTAL SAVINGS ($)	TOTAL COSTS ($)	COST AVOID ($)	PAYBACK PERIOD (MOS)
3.10	0	0	0	0	188,675	0
3.11	0	0	0	0	0	0
3.12	0	0	0	0	234,580	0
3.13	0	0	0	0	902,000	0
3.14	0	0	0	0	0	0
3.15	0	0	0	0	0	0
3.16	0	0	0	0	0	0
3.17	0	0	0	0	6,300,000	0
3.18	0	0	0	0	3,900,000	0
3.19	0	0	0	0	0	0
3.20	0	0	0	0	0	0
3.21	0	0	0	0	1,000,000	0
3.22	0	0	0	0	17,000,000	0
3.23	0	0	0	0	15,000,000	0
3.24	0	0	0	0	0	0
Su	0/0	0	0	0	44,525,255	--
Total	7.3/1.8	1,085,345	2,707,975	400,760	45,210,463	--

APPENDIX G

NSC PENSACOLA RECEIPT PROCESSING SECTION
RELATED MEANS DIFFERENCE TEST

Employee	Dec-Jan	Feb-Mar	d_i
A	59.14	48.50	10.64
B	0	45.25	-45.25
C	70.66	77.37	-6.71
D	59.33	45.91	13.42
E	48.93	71.88	-22.95
F	41.28	54.30	-13.02
G	105.17	96.88	8.29
H	110.88	112.55	-1.67
I	35.63	70.95	-35.32
J	47.41	55.40	-7.99
K	74.56	82.28	-7.72
L	68.03	76.64	-8.61
M	67.64	65.39	2.25
N		39.92	0
Mean	66.79	71.56	-114.64
Mean d_i			-8.18857

APPENDIX H

NSC PENSACOLA PACKING AND CRATING SECTION TWO
RELATED MEANS DIFFERENCE TEST

Employee	Dec-Jan	Feb-Mar	d_i
A	77.03	97.03	-20.00
B	56.00	66.84	-10.84
C	94.18	87.48	6.70
D	79.27	57.02	22.25
E	89.03	89.78	-0.75
F	20.43	20.85	-0.42
G	66.00	59.89	6.11
H	83.69	93.55	-9.86
I	84.51	93.26	-8.75
J	74.97	77.56	-2.59
K	102.16	97.00	5.16
L	43.26	48.02	-4.76
Mean	72.257	74.08	-17.75
Mean d_i			-1.47916

APPENDIX I

NSC PENSACOLA RECEIPT PROCESSING EMPLOYEE PRODUCTIVITY VALUES

Employee	1	2	3	4	5	6	7
A			68	55			
B							
C	53	66	103	89	64	78	44
D	83	73	57	56	48	31	48
E	41	102	56	50	53	13	63
F			50	43	33	13	38
G	53	74	140		144	97	100
H	64	127	134	166	131	98	119
I	66	63					
J	42		56	60		41	70
K	69	104	69	65	55	47	86
L	96	55		69	46	28	48
M	69	77		71	86	20	42
N							

Employee	8	9	10	11	12	13	14	15
A	75	55	62	50	45	100	92	73
B								
C	114	15	65	64	56	98	49	51
D				31	58	88	76	69
E	54	32	54	42	48			
F	55	38	35	40	71			
G	75	85	73		151	156	121	118
H	114	116	77	103			112	118
I								
J	77	25	84	43	50	82	51	61
K	58	90	89	85		52	113	
L	54	50		53	32	85	75	73
M	63	58	67	79				
N								

Employee	16	17	18	19	20	21	22	23
A	106					64	75	63
B								
C		144	82	54	76	74	93	60
D		73	68	46	46	73	57	73
E						41	51	68
F			64	66	38	37	48	0
G	88	163	136	145		95	73	117
H						107	86	142
I								
J		26	36	45				40
K		88	109	41	53	106	97	128
L	61	106	85	87	78	61	120	117
M						50	73	91
N								

24	25	26	27	28	29	30	31
		37	38	39	7	70	59
46	31	97	72	58	46	73	91
48	22	49	44	73	14	71	60
44	11	47	49	42	52		
33	31						38
84	62	75	82	107	106	92	110
107	83	76	87				
22	47	29	16	18	9	34	52
18	14	56	33	59	58	54	51
53	48	86	88		16		85
36	9						94
64	57	66	77	88	60	98	76

32	33	34	35	36	37	38	39
56	42	60	45	39	72	56	53
51	32	69	100	112	72	63	80
78			69	83	78	57	58
36	25	79	44		51	73	
41	29	68	43	56	55	69	65
159	149	132	142	92	85		
			96	131	140	122	116
55	44	38	41	44	43	41	15
63	29				51		
89	43	76	62	90	46		
48	31	75		63	105	98	71
64	34	70		71	72	68	83

No. Obs.	Mean	Gp.Mean	Variance	Gp.Var.	Std.Dev.	Gp.Std.De
28	59.14285		406.6224		20.16488	
1	0		0		0	
38	70.65789		644.6987		25.39091	
33	59.33333		315.6767		17.76729	
27	48.92592		334.4389		18.28767	
29	41.27586		385.6480		19.63792	
35	105.1714		1254.542		35.41951	
25	110.88		550.8256		23.46967	
19	35.63157		317.6011		17.82136	
29	47.41379		379.5529		19.48211	
32	74.5625		620.4335		24.90850	
31	68.03225		727.1279		26.96531	
28	67.64285	66.79154	271.1581	1010.457	16.46688	31.78770

Employee	40	41	42	43	44	45	46
A				62	56	62	77
B							
C	82	61	107	117	83	58	117
D	48	61	50	52	50	61	50
E	62	76	59	70	74	67	75
F	47	40	66	37		33	44
G	99	95	96	106	127	86	130
H	86	119	116			68	148
I	34	53	68	55	27	72	56
J	56	62	59	52		61	60
K	84	96	93	65		51	104
L	68	72	76	58	50		51
M	65	67	69	34	56		53
N							

47	48	49	50	51	52	53	54
49	61	47		60	52	44	52
				102	79		
133	81	75	78	134	126	92	72
40	43	49	63	49	45	37	36
61	49	73		69	71	59	94
33	65	64	63	84	62	58	
131	73	115	120	107	57	81	62
155	109	92	124	139	120	98	60
46	36	44	81	51	65	58	53
41	32	41	52	81	56	43	46
96	29	112	101	107	117	33	70
53	58	49	48	87	109	79	53
68	49	44	65	115	131	55	42

55	56	57	58	59	60	61	62
57	27	36	34				
60	74	62	105	91	86	54	106
59	48	26	45	38	36	54	56
74	68	102	87				110
	37	97	49	35	41	94	36
82		81	82	90	82	120	89
102	171	139	78	89	144	125	94
65	110	80	99	58	47	80	105
55	47	39	48	52	61	59	48
93	52	68	102	87	62	82	
55	52	81	60	69	94	73	127
78	61	74	67	59	73	50	71
						15	27

63	64	65	66	67	68	69	70
61	107	82	75	41	99	58	74
53	53	44	49	41	45	47	53
78	77	85	63	78	90	60	92
	38	56	54	56			42
	117	126	68	77	98	135	66
116	112	125	117	118	100	139	90
91	121	44	81	71	106	57	130
	55	56	44	44	84	58	64
	93	98	83	76		88	118
106	76	84	66	41	105	87	88
64				44	83	79	86
0	34	45	58	36	64	50	46

71	72	73	74	75	76	77	78
64	31		84	56	76	6	
39	36	39	60	51	54	44	40
55	92	54	95	81	63	49	97
76	58		63	87	61	54	56
74	99	77	102	172	132	109	73
87	172	84		110	154	122	90
70	69	35	78	112	79	57	59
72	61	26		87	48	60	58
76	66	47	69	126	76	58	77
121	96	48	93	95	71	85	78
72	88	54	49	78	55	33	44
51	48	45					

79	80	81	82	No. Obs.
				16
				4
74	41	28	61	41
50	42	38		43
55	58	55	98	40
42	63	49	69	37
69	76		94	40
54	71	122	143	40
65	106	89	88	43
67	60	59	62	40
93	81	92	88	39
103	70	75	109	42
65		73	72	38
				13

APPENDIX J

NSC PENSACOLA PACKING AND CRATING EMPLOYEE PRODUCTIVITY VALUES

Employee	1	2	3	4	5	6	7
A	61	58	91	115	118	50	6
B	0	0	0	0	0	0	0
C	45	129	56	66	53	89	76
D	145	65	78			64	96
E			136	44	100	52	89
F	50	95		52	14	40	4
G	64	84	59	64	49	67	85
H	67		91	87	49	4	
I	104	92	102	94	62	92	92
J	81	58	93	114	116	56	0
K	0	0	118	0	112	107	107
L	40	90	114	90	107	103	103

Employee	8	9	10	11	12	13	14	15
A	71	71	52	49	60			
B	0	0	0	0	13	60	60	
C	108	48	82	73	131	130		
D	98	61	159	88				57
E	45	95	68	119	96	75	14	92
F	92	22	0	58	0	0	0	
G	50	53	47	39	60			
H			86	73	76			
I	57	73	87	89	74	76	41	52
J	0	78	33	61	60	62	62	149
K	106	56	87	170	0	198	160	132
L	77	60		84	50	73	48	60

Employee	16	17	18	19	20	21	22	23
A								55
B							47	75
C						105	68	102
D	73		114	60	117	92	157	75
E						91	152	72
F		154	154	0		0	0	0
G						54	41	34
H		54		121	75		160	83
I		83	92	82	96	113	89	60
J	115		62	123	89	51	44	72
K	103	47	112	112	97	108	73	97
L	33					0	107	87

24	25	26	27	28	29	30	31
52	83	69	89	59	33	90	117
45	51	66	68	64	80	106	90
			69	141	75	129	244
117	96	105	101	122	114	147	123
52		56	97	77	51	152	145
0	0	0	0	0	0	0	0
38	91	84	101	105	72	87	85
123	94		82	114	71	68	101
57		104	107	79	90	64	123
60	65	65	66	80	47	107	85
94	89	100	86	85	78	173	156
88	57	0	0	0	0	0	0

32	33	34	35	36	37	38	39
143	53	67	113	115	65	117	112
125	120	159	149	114	114	130	
80	69	70	89	114	92	104	
0	0	0	74	0	0	0	18
119	60	95	67	115	84	133	117
0	0	0	0	0	0	0	0
69	55	77	80	61	65	60	
	54	63		83	100	111	86
94	111	95	97	90	77	100	37
	77	154	144	68	84	60	33
172	158	81	136	114	114	144	
0	0	0	0	0	0	0	0

No. Obs.	Mean	Gp. Mean	Variance	Gp. Var.	Std.Dev.	Gp.Std.De
29	77.03448		951.7574		30.85056	
31	56		2639.483		51.37590	
28	94.17857		1541.146		39.25744	
33	79.27272		2296.016		47.91676	
31	89.03225		1163.708		34.11317	
35	20.42857		1693.102		41.14732	
30	66		340.0666		18.44089	
26	83.69230		840.5976		28.99306	
37	84.51351		388.5200		19.71091	
37	74.97297		1212.134		34.81572	
38	102.1578		2306.185		48.02276	
34	43.26470	72.25706	1801.135	1962.643	42.43979	44.30173

Employee	40	41	42	43	44	45	46
A	136	115	103	82	94	115	101
B	64	75	55	87		112	81
C		118	100	99	25	152	53
D	0	0	0	0	0	0	0
E		112	65	61	15	124	94
F	0	0	0	0	0	0	0
G				56	70	41	78
H	94	70	42	34	61	89	77
I	88	100	36	96	56	78	97
J	63	77	120	107	60	101	85
K	88	92	71	116	53	68	93
L						0	0

47	48	49	50	51	52	53	54
64	79	0		119	101	71	103
64	30	0	0	17	72	86	
	71			53	70	149	38
0	0	0	0	11	0	34	119
90	78			81			98
0	0	0	0	0	0	0	0
31	58	120		68	52	64	80
73	90	100	63	135	139	136	170
110	72	67	105	108	119	97	109
43			0		59	76	42
50	99		85	57	110		227
0	0	63	64	0	25	30	0

55	56	57	58	59	60	61	62
53	61	98	82		58	102	117
30	80	28	69	62	76	65	87
61	53	107	103	81	82	67	101
92	81	0	58	45		43	148
33	117	57	69	132	103	69	110
0	0	0	0	0	0	0	0
69	91	60	90	58	54	80	46
123	84	68	83	73	39	64	94
116	114	74	82	66	113	101	101
122	154	100	64	66	99	15	41
227	227	52	200	115	97	96	96
0	0	65	6	116	76	90	51

63	64	65	66	67	68	69	70
122	127	56	121	81	128	111	67
91	53	76	99	78	82	78	81
89	94	68	81	79	115	73	145
109	108	101	83	75	28	134	64
48	129	58	101	119	56	98	65
0			0	0	0	92	10
			55	38	75	118	69
94	170	136	71	114	103	107	96
102		70	78		85		89
68	25	40	81	74	98	88	99
110	97	96	122	92	74	34	111
70	29	79	20	85	62		69

71	72	73	74	75	76	77	78
69	125	109	104		159	102	125
76	97	82			72	47	
89	76	65	133	65	104	75	152
80	120	115	89		105	66	41
96	79		98	127	120	115	105
13	0	57	17	23	50	61	
43	87	82	85	98	80	0	0
83	114	142	80	114	119	89	
110	97	93	108	113	98		118
74	95		128	79	65	56	118
73	105	89	100	102	111	117	89
39	72	62	88	65	123	102	11

79	80	81	82	Nr. Obs.	Mean	Gp.Mean
98	101	122	100	41	97.025	
80		87	54	38	66.83783	
163	72	0	108	41	87.475	
62	112	95	120	42	57.02439	
102	122	60	116	38	89.78378	
124	138	125	124	41	20.85	
	0	0	0	36	59.88571	
		59	50	41	93.55	
108	97	65	101	40	93.25641	
76	129	86	52	40	77.56410	
71	0	114	48	43	97	
105	91	92	119	42	48.02439	74.07643

Variance	Gp.Var.	Std.Dev	Gp.Std.De
826.3243		28.74585	
663.8115		25.76454	
1302.649		36.09223	
2297.535		47.93261	
824.7640		28.71870	
1676.327		40.94297	
986.2155		31.40406	
1075.847		32.80011	
357.8316		18.91643	
1044.451		32.31796	
2400.428		48.99416	
1647.292	1812.270	40.58684	42.57076

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Code 401
Naval Supply Center
Oakland, California 94625

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Process Control Officer
Naval Supply Center
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13. LCDR Patrick A. Elliott, SC, USN 1
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14. Professor Alan W. McMasters, Code 54Mg 3
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